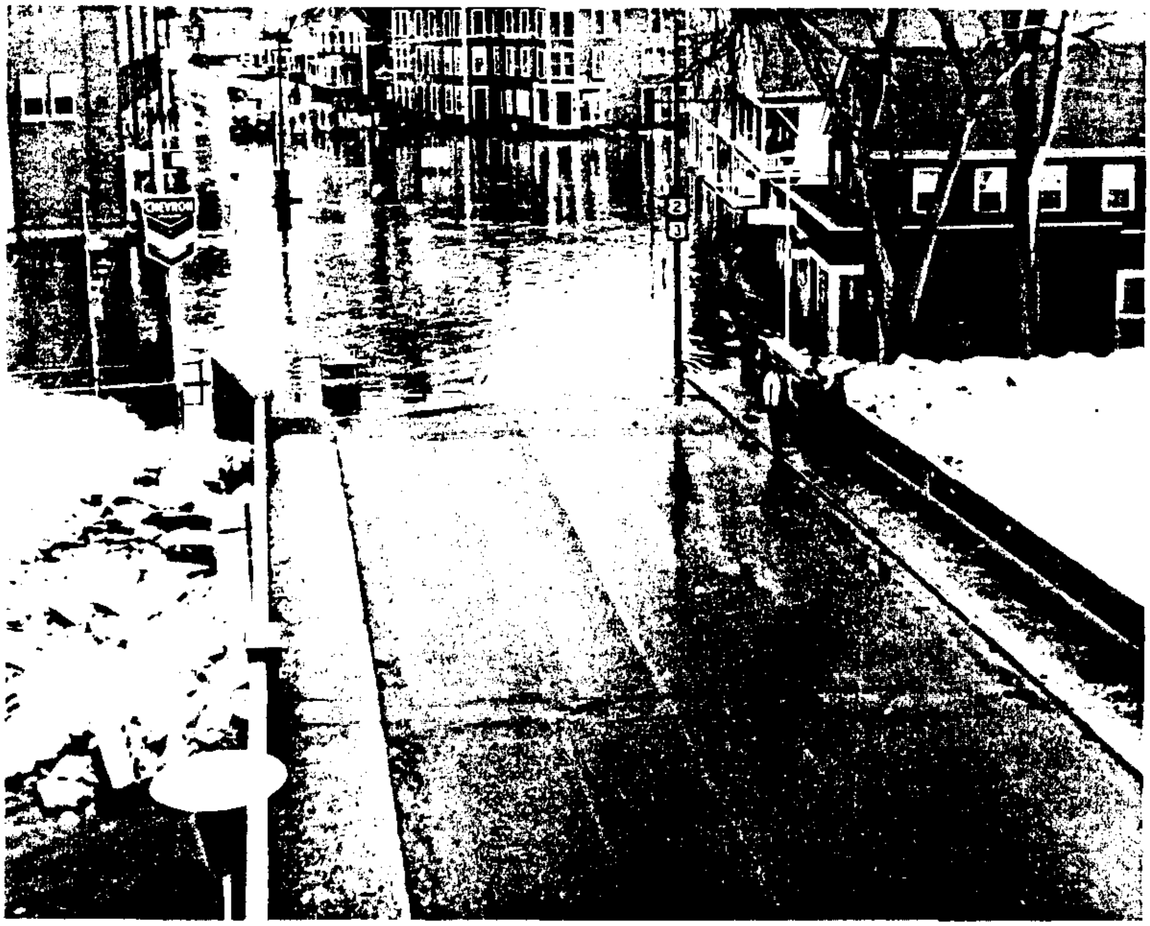
SECTION 206: FLOOD PLAIN MANAGEMENT ASSISTANCE

HISTORICAL ICE JAM FLOODING IN MAINE, NEW HAMPSHIRE AND VERMONT



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New England Division

OCTOBER 1980

ACKNOWLEDGMENTS

The Planning Division, New England Division, U.S. Army Corps of Engineers prepared this report under the provisions of Section 206 of the 1960 Flood Control Act which authorizes the Corps to provide engineering advice to reduce flood hazards. It was prepared by Mr. James E. McLoughlin, Study Manager under the direction of Mr. Paul E. Pronovost, Chief, Flood Plain Management Services Section. Study team members included Mr. Francis Hibbard, Mr. Robert Key, Mr. Mark Pavluvcik, Ms. Mary Riccio, Mr. Martin Sigel, Ms. Ann Wright, Mrs. Marianne Conway, Mrs. Frances Porter, and Mrs. Camille Santi.

A special acknowledgment is also extended to the many state and local officials who provided the report with the majority of information presented.

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I INTRODUCTION

Ice jams have historically been a source of flooding throughout New England. This type of flooding can occur in any area where temperatures fall below zero degrees Celsius ($0^{o}C$) and cause rivers and lakes to freeze Because of the more severe winter conditions in the three northern New England states of Maine, New Hampshire and Vermont, ice jam flooding is a recurring problem.

As part of its technical services program the Corps of Engineers has prepared this report in an effort to assist the states of Maine New Hampshire and Vermont. It is intended that this report be used by Federal, State and local officials as a guide in identifying areas prone to ice jam flooding and possible remedial measures to be taken in the event of ice jam flooding.

Existing flood plain management zoning regulations of most communities have customarily been based on analyses of natural flow conditions, neglecting the influence of ice jams. Local officials should be aware that ice jam flooding conditions often exceed predicted natural floods, and that additional flood plain management may be advisable for areas subject to frequent ice jam flooding

Included in this report is historical information on ice jam flooding in selected communities. After analyzing all available data, these communities were selected as having recurrent ice jam problems as well as significant damages or potential damages caused by ice jam flooding. The selected communities are highlighted on Plates 1-3. Communities not mentioned in this report may be subject to ice jam flooding and their exclusion from this study in no way indicates that they are immune to ice jam problems. Any area where freezing temperatures occur may be subject to ice jamming.

II. PURPOSE AND AUTHORITY

The states of Maine, New Hampshire and Vermont requested assistance from the New England Division, Corps of Engineers in preparing a manual on ice jam flooding. The purpose of this report is to provide the states with a manual describing the frequency and extent of historical ice jam flooding together with possible solutions.

Authority for Corps of Engineers participation in this effort is contained in Section 206 of the 1960 Flood Control Act (Public Law 86-645) which states

> ". . The Secretary of the Army through the Chief of Engineers, Department of the Army, is hereby authorized to compile and disseminate information on floods and flood damages, including identification of areas subject to inundation by floods of various magnitudes and frequencies, and general criteria for guidance in the use of flood plain areas and to provide engineering advice to local interests for their use in planning to ameliorate the flood hazard. . . "

III. SCOPE OF STUDY

The study area, shown on Plates 1-3 includes all communities within the states of Maine, New Hampshire and Vermont.

This report encompasses all known ice jam flooding in the three states that has occurred since 1 January 1970 (Tables 1-3). It was assumed that areas where ice jams had occurred prior to 1970 may not be representative of present hydrologic and hydraulic stream conditions. Sites where ice jams have occurred since 1970 represent (but not exclusively) areas of future ice jam flooding. However, as noted later, ice jam flooding can also occur in areas with a limited history of such flooding. North Stratford, New Hampshire is a recent example where severe damages occurred almost without precedent.

Federal, State and local officials were contacted in an effort to identify all areas subject to ice jam flooding. U.S. Army Corps of Engineer files were searched to identify communities which had been assisted by the Corps during ice jam flooding. Other sources consulted at the Federal level were the Federal Emergency Management Agency and the Small Business Administration. At the State level, the Maine State Planning Office, Maine Bureau of Civil Emergency Preparedness, The New Hampshire Office of State Planning, New Hampshire Office of Civil Defense, Vermont Department of Water Resources and Vermont Department of Public Safety were all contacted for information on ice jam flooding. In areas considered to have more serious ice jam problems, local officials through onsite interviews provided detailed information which was used to document past ice jam flooding.

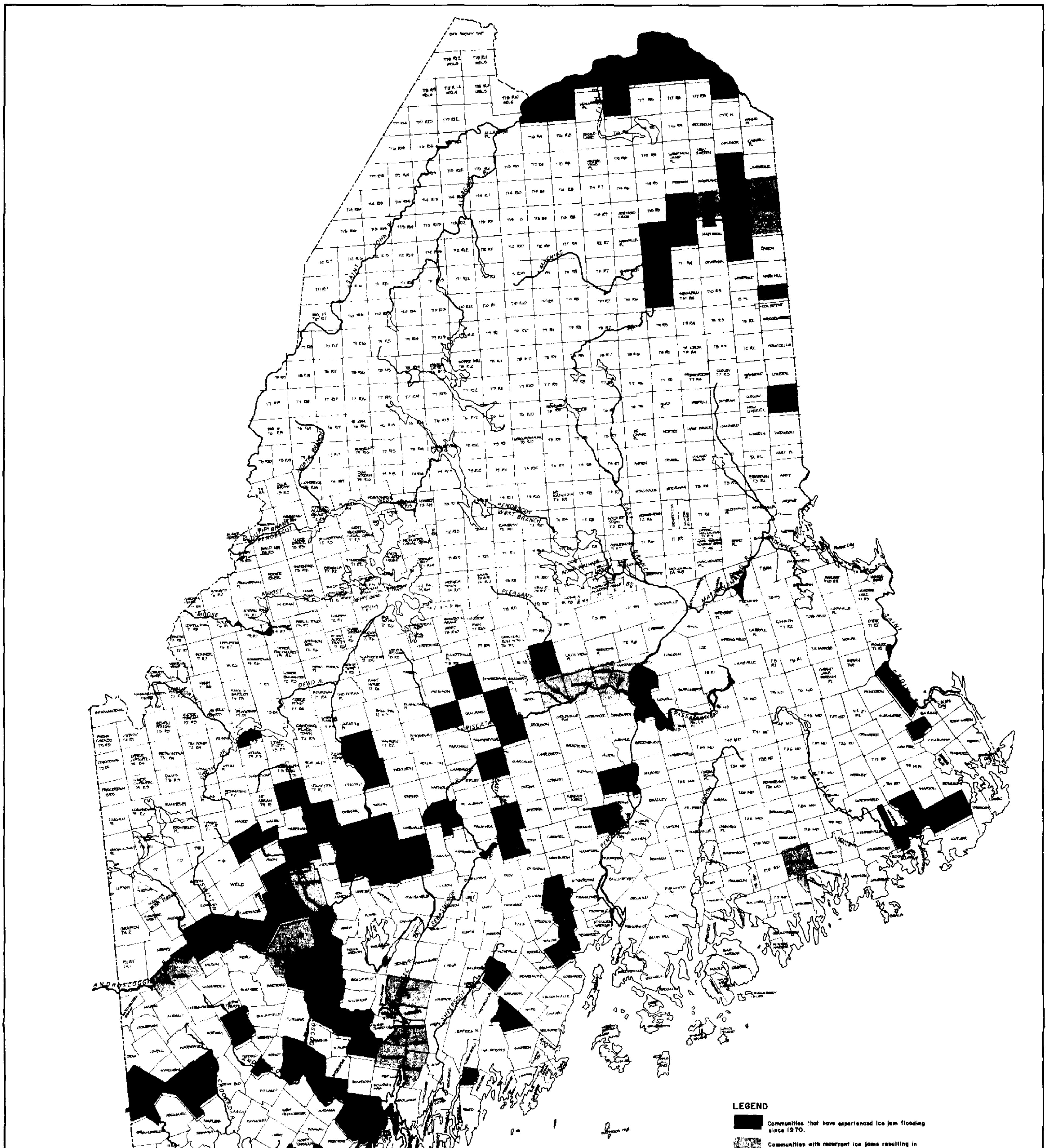
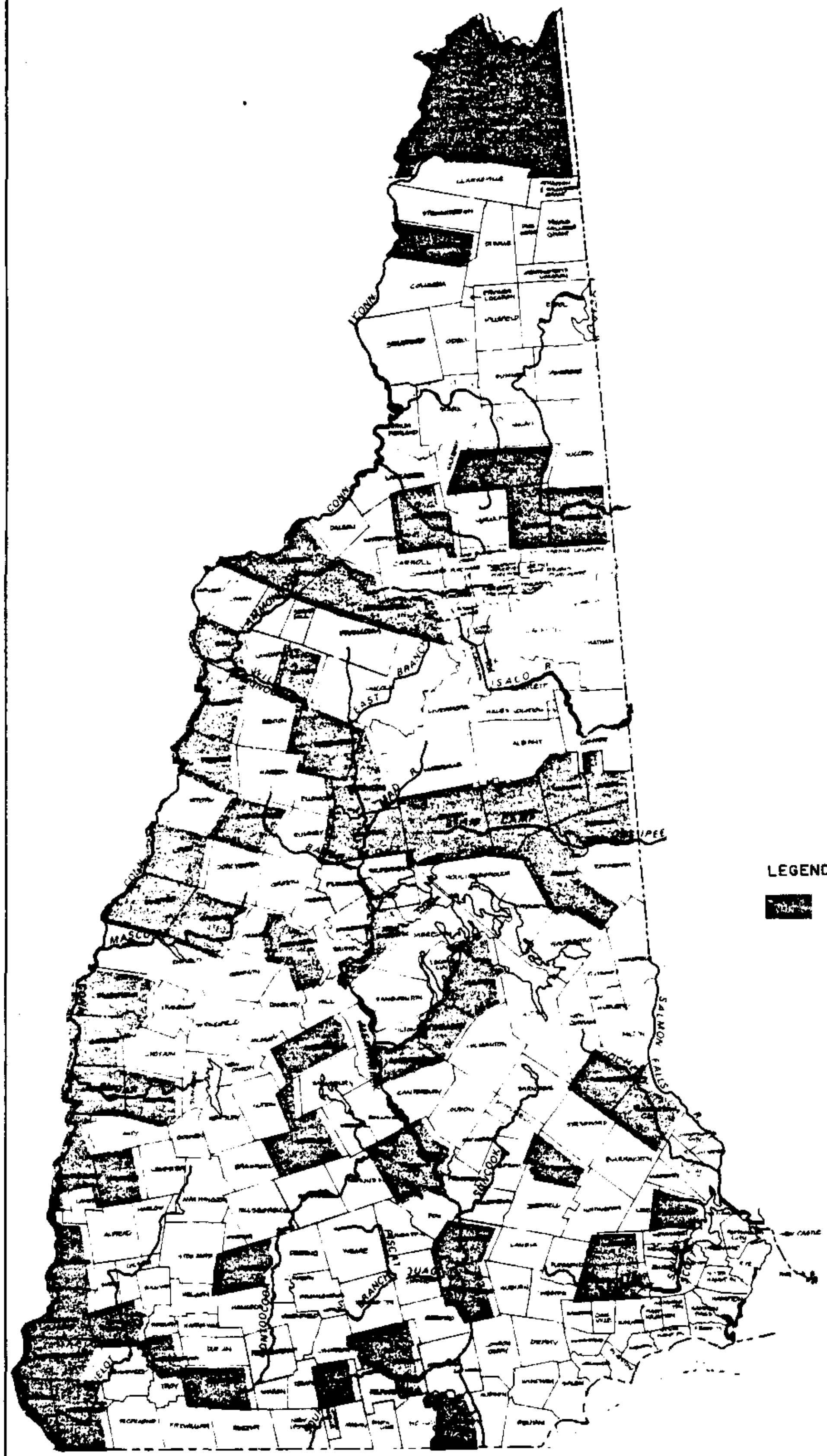

LEGEND
Communities that have experienced ice jam flooding since 1970.
Communities with recurrent ice jams resulting in significant flood damages.
ANDROSCOGGIN R.
OSSIPEE R.
SALMON FALLS R.
PENOBSCOT WEST BRANCH
MOOSE R.
DEAD R.
WELD
PERU
POLAND
WELLS
LEBANON
STATE OF MAINE
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MA.

PLATE I



LEGEND

Communities that have experienced ice jam flooding since 1970

Communities with recurrent ice jams resulting in significant flood damages.

STATE OF NEW HAMPSHIRE
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION CORPS OF ENGINEERS
WALTHAM, MA.

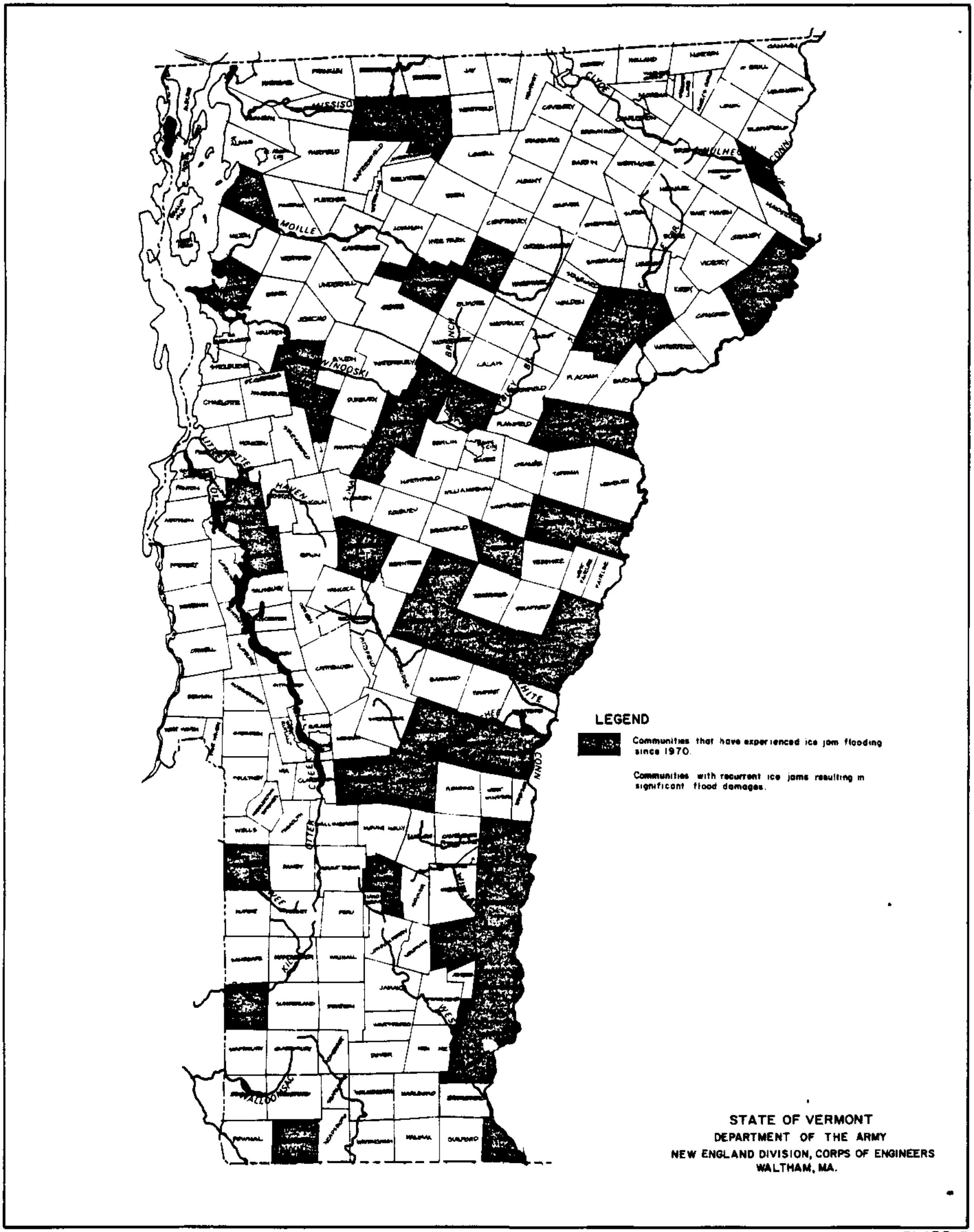

LEGEND
Communities that have experienced ice jam flooding since 1970.
Communities with recurrent ice jams resulting in significant flood damages.
STATE OF VERMONT
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MA.

PLATE 3

TABLE 1

MAINE COMMUNITIES THAT HAVE EXPERIENCED

ICE JAM FLOODING SINCE 1 JANUARY 1970

Community	Stream	Date/Frequency
Abbot	Piscataquis River	
Anson	Kennebec River	1973
Ashland	Aroostook River	Apr, Dec 1973, May 1974, Apr 1976
Auburn	Androscoggin River	Jan 1978
Augusta	Kennebec River	Annual[1]
Baileyville	Wapsaconhagan Brook	Jan 1978
Bangor	Penobscot River	1975
Bath	Kennebec River	Mar 1978
Belfast	Passagassawakeag River	2/10 years[1]
Bethel	Androscoggin River	4/10 years[2]
Bigelow	Wyman Stream	Feb 1971
Bingham	Kennebec River	Feb 1972
Blaine/Robinsons	Prestile Stream	1973
Bridgton	Stevens Brook	1/10 years
Brunswick	Androscoggin River	Mar 1978
Brownville	Pleasant River	1/10 years[1]
Canton/Gilbertville	Androscoggin River	3/10 years[2]
Caribou	Aroostook River	Apr, Dec 1973, May 1974, Apr 1976
Castle Hill	Aroostook River	Apr, Dec 1973 May 1974, Apr 1976
Chelsea	Kennebec River	Annual[3]
Cherryfield	Narraguagus River	3/10 years[1]
Chesterville/ Farmington Falls	Sandy River	Mar 1970, Jan 1978
Cumberland		
Damariscotta	Damariscotta River	1/10 years[1]
Dexter	East Branch Sebasticook River	1/10 years[1]
Dickey	St. John River	Annual[1]
Dixfield	Androscoggin River	1977
Dover-Foxcroft	Piscataquis River	Feb 1973
Dresden	Kennebec River	Annual[2]
East Machias	East Machias River	Jan 1978
Enfield	Cold Stream	Apr 1976
Farmingdale	Kennebec River	Annual[2]
Farmington	Sandy River	Annual[2]
Fayette		
Fort Fairfield	Aroostook River	Apr, Dec 1973, May 1974, Apr 1976
Fort Kent	St. John River	May 1974
Frenchville	St. John River	Apr, Dec 1973, May 1974, Apr 1976

TABLE 1 (Cont.)

Community	Stream	Dates/Frequency
Fryeburg	Saco River	Mar 1970, Mar 1978
Gardiner	Kennebec River	Annual[3]
Grande Isle	St. John River	
Hanover	Androscoggin River	Jan 1978
Hallowell	Kennebec River	Annual[3]
Hartland	Sebasticook River	Mar 1975
Houlton	Meduxnekeag River	2/10 years[1]
Howland	Piscataqua	6/10 years[2]
Jay	Androscoggin River	Jan 1978
Kingfield	Carrabassett River	Mar 1976
Leeds	Androscoggin River	Jan 1978
Lewiston	Androscoggin River	Jan 1978
Liberty	Little Pond	
Lisbon	Androscoggin River	Jan 1978, Mar 1978
Litchfield		
Livermore	Androscoggin River	Jan 1978
Livermore Falls	Androscoggin River	Jan 1978
Machias	Machias River	Jan 1978
Madison	Kennebec River	Feb 1973
Masardis	Aroostook River	Apr, Dec 1973, May 1974, Apr 1976
Maxfield	Piscataquis River	6/10 years[2]
Mechanic Falls	Little Androscoggin River	1/10 years[1]
Meddybemps	Dennys River	Mar 1976
Medford	Piscataquis River	6/10 years[2]
Mexico	Androscoggin River	Jan 1978
Milo	Pleasant and Piscataquis Rivers	6/10 years[2]
Monmouth	Cochnewagon Lake	Jan 1978
Monroe	North Branch Marsh Stream	Jan 1978
Moscow	Austin Stream	Feb 1975
New Canada/Daigle	Daigle Brook	Mar 1978
Newport	East Branch Sebasticook River	1/10 years[1]
New Portland	Carrabassett River	Mar 1976
New Vineyard	Lemon Stream	2/10 years
Norridgewock	Kennebec River	Jan 1970, Feb 1973
Old Town	Penobscot River	Mar 1973
Paris	Stony Brook	Feb 1972
Passadumkeag	Passadumkeag River	
Phillips	Sandy River	Feb 1973, Jan 1978, Mar 1978
Pittston	Kennebec River	Annual[3]
Plymouth	Martin Stream	
Presque Isle	Presque Isle Stream and Aroostook River	Apr, Dec 1973, May 1974, Apr 1976
Randolph	Kennebec River	Annual[3]
Richmond	Kennebec River	Annual[3]
Rumford	Androscoggin River	Mar 1970, Jan 1978
St. Agatha	Factory Brook	May 1974
St. Francis	St. John River	1/10 years[1]
St. John	St. John River	1/10 years[1]

TABLE 1 (Cont.)

Community	Stream	Dates/Frequency
Sanford	Mousam Brook	Feb 1972
Skowhegan	Kennebec River	Jan 1970, Jan 1976
Starks	Sandy River	
Strong	Sandy River	
Swanville	Goose River	Jan 1978
Temple	Temple Stream	4/10 years[3]
Topsham	Androscoggin River	Jan 1978
Union	St. George River	Jan 1978
Van Buren	St. John River	1/10 years[1]
Wade	Aroostook River	Apr, Dec 1973, May 1974, Apr 1976
Washburn	Aroostook River	Apr, Dec 1973, May 1974, Apr 1976
Wayne	Pocasset Lake	Mar 1975
Westbrook	Presumpscot River	Dec 1974
Whiting	Orange River	Jan 1978
Whitneyville	Machias River	Jan 1978
Willimantic	Big Wilson Stream	Feb 1973
Wilton	Wilson Stream	Feb 1970, Jan 1978
Yarmouth	Royal River	Mar 1978

Footnotes:

[1] Information furnished by State Civil Defense
[2] Information furnished by Local Civil Defense Director
[3] Information furnished by Town Official

TABLE 2

NEW HAMPSHIRE COMMUNITIES THAT HAVE EXPERIENCED

ICE JAM FLOODING SINCE 1 JANUARY 1970

Community	Stream	Dates/Frequency
Acworth	Cold River	1979, Infrequent[1]
Alexandria	Fowler River	Feb 1973
Allenstown	Suncook River	Mar 1977 5/10 yrs[2]
Amherst	Souhegan River	Mar 1977
Andover	Blackwater River	Mar 1977
Antrim	Contoocook River	Mar 1977
Ashland	Pemigewasset River	Mar 1975
Bath	Ammonoosuc River	Mar 1977
Belmont	Durgin Brook	Mar 1977
Berlin	Androscoggin River	
Bethlehem	Ammonoosuc River	Feb 1973
Brentwood	Exeter River	Mar 1977
Campton	Pemigewasset River	Jan 1976
Canaan	Mascoma River	6/10 yrs[1]
Charlestown	Connecticut River	Feb 1970, Feb 1976
Chesterfield	Connecticut River	Feb 1970
Claremont	Sugar and Connecticut Rivers	Mar 1977
Colebrook	Mohawk River	
Concord	Merrimack and Soucook Rivers	Mar 1977
Conway	Saco River	Annual[3]
Cornish	Connecticut River	Feb 1973, Feb 1979
Durham	Lamprey River	Mar 1977
Easton	Ham Branch River	Mar 1977
Eaton	Snow Brook	Mar 1977
Epping	Pawtuckaway River	Mar 1977
Farmington	Cocheco River	Mar 1977
Franconia	Gale River	9/10 yrs[3]
Freedom	Ossipee River	Mar 1977
Fremont	Exeter River	Mar 1977
Gilford	Meadow Brook	Mar 1977
Gorham	Androscoggin River	
Hanover	Connecticut River	Mar 1977
Haverhill	Ammonoosuc River	
Henniker	Contoocook River	Annual[2]
Hinsdale	Connecticut River	Jan 1976, Jan 1979
Holderness	Pemigewasset River	Annual[1]
Hooksett	Merrimack River	Mar 1977
Jaffrey	Contoocook River	Infrequent[1]
Jefferson	Israel River	3/5 years[1]
Keene	Ashuelot River, Beaver and Minnewawa Brook	Jan 1975, Mar 1977
Lancaster	Israel River	Feb 1973, Mar 1977 Jan 1978

TABLE 2 (Cont.)

Community	Stream	Dates/Frequency
Lebanon	Connecticut and Mascoma Rivers	3/10 years[3]
Lisbon	Ammonoosuc River	Annual[3]
Littleton	Ammonoosuc River	
Lyme	Connecticut River	Mar 1977
Madison		
Manchester	Merrimack River	Mar 1977
Marlborough	Branch River	3/5 yrs[1]
Merrimack	Souhegan River	Annual[3]
Milford	Souhegan River	
Mount Vernon	Beaver Brook	Mar 1977
Nashua	Nashua River	Mar 1977
New Hampton	Pemigewasset River	Mar 1977
Newport	Sugar River	Frequent[1]
Northfield	Winnipesaukee River	Mar 1977
Northwood	Sherburne Brook	Mar 1977
Ossipee	Bearcamp River	Infrequent[1]
Pembroke	Suncook River	5/10 years[2]
Peterborough	Contoocook River	Annual[2]
Piermont	Eastman Brook and Connecticut River	Infrequent[1]
Pittsburg	Halls Stream	Mar 1977
Plainfield	Connecticut River	Feb 1970
Plymouth	Baker and Pemigewasset Rivers	Annual[1]
Raymond		
Rochester	Baxter Lake	Mar 1977
Sandwich	Montgomery Brook	Infrequent[1]
Shelburne	Androscoggin River	
Stratford	Connecticut River	Annual[1]
Sugar Hill	Gale River	9/10 years[3]
Tamworth	Bearcamp River	Infrequent[1]
Thornton	Pemigewasset and Beebe Rivers	Frequent[1]
Walpole	Connecticut River	Feb 1970
Warner	Lane River	Infrequent[1]
Wentworth	Baker River	Frequent[1]
Westmoreland	Connecticut River	Feb 1970
Wilton	Souhegan River and Stony Brook	Frequent[1]
Winchester	Ashuelot River	Infrequent[1]
Woodstock	Pemigewasset River	Frequent[1]

Footnotes:

[1] Information furnished by State Civil Defense
[2] Information furnished by Local Civil Defense Director
[3] Information furnished by Town Official

TABLE 3

VERMONT COMMUNITIES THAT HAVE EXPERIENCED ICE JAM FLOODING SINCE 1 JANUARY 1970

Community	Stream	Dates/Frequency
Arlington	Batten Kill	Jan 1979
Barre	Stevens Brook	
Bethel	White and Third Branch White Rivers	
Bradford	Waits River	Feb 1973, Jan 1976, Feb 1976
Brattleboro		Jan 1976 (2), Jan 1979
	Whetstone Brook	4/10 years[3]
Bridgewater	Ottauquechee River	Feb 1976
Brookline	West River	Jan 1979
Brunswick	Connecticut River	Annual[1]
Cambridge	Lamoille River	Annual[3]
Cavendish	Black River	Feb 1976
Chelsea	First Branch White River	Feb 1973, Dec 1976, Jan 1978
Chester	Williams River	Feb 1974, Feb 1975, Apr 1975
	Middle Branch Williams River	Feb 1976, Jan 1978, Mar 1978
	South Branch Williams River	Annual[3]
Colchester	Winooski River	Jan 1973
Corinth	Waits River	Mar 1972, Feb 1978
Danville	Joe´s Brook	Feb 1976
Dummerston	Connecticut River	Feb 1970
East Montpelier	Winooski River	
Enosburg	Missisquoi River	
Georgia	Lamoille River	
Grafton	Saxtons and South Branch Rivers	Feb 1973
Granville	White River	Annual[3]
Groton	Wells River	
Guildhall	Connecticut River	
Harwick	Lamoille River	Dec 1972,Jan 1973 Dec 1973, Jan 1974,Dec 1976,Jan 1978, Jan 1979
Hartford	Ottauquechee, White, and Connecticut Rivers	Feb 1970 Annual[3]
Hartland	Connecticut River	Feb 1970
Huntington	Huntington River	Feb 1976
Isle LaMotte	Lake Champlain	Mar 1975
Jeffersonville	Brewster River	Jan 1973
Ludlow	Black River	Feb 1976
Lunenburg		
Lyndon	Branch and Sheldon Brooks Miller Run, West Branch Passumpsic and Passumpsic Rivers	Annual[3]

TABLE 3 (Cont.)

Community	Stream	Dates/Frequency
Middlebury	Otter Creek	Feb 1976
Middlesex	Winooski River	Mar 1978
Montgomery	West Hill Brook	Jan 1976
Montpelier	Winooski River	Mar 1974,Jan 1978, Mar 1978
Moretown	Mad River	Jan 1973, Mar 1978
Morristown	Lamoille River	
New Haven	New Haven River	Jan 1976
Norwich	Ompompanoosuc River	Feb 1976
Pawlet	Flower and Metawee Brooks	
Plymouth	Black River	Feb 1976 (2)
Putney	Connecticut River	Feb 1970
Randolph	White River	Feb 1976
Richford	Missisquoi River	Feb 1973,Jan 1974,Mar 1974, Apr 1978, Jan 1979,
Richmond	Winooski River	Jan 1976
Rochester	White River	Annual[3]
Rockingham	Saxtons and Connecticut Rivers	Feb 1970, Feb 1976
Royalton	White River	
Ryegate	Connecticut River	Mar 1977
St. Johnsbury	Moose and Passumpsic Rivers	Jan 1973, Feb 1973
Sharon	White River	
Shrewsbury	Mill River	
Springfield	Connecticut River	Feb 1970
Stamford	North Branch Hoosic River	Jan 1979
Stowe	Little River	Mar 1976
Taftsville	Ottauquechee River	
Thetford	Ompompanoosuc River	Feb 1976
Tunbridge	First Branch White River	Feb 1973, Feb 1976
Vernon	Connecticut River	
Wardsboro		
Waitsfield	Mad River	Jan 1976
Weathersfield	Connecticut River	Feb 1970
Westminstr	Connecticut River	Feb 1970
Weston	West River	Jan 1979
Wilmington	North Branch Deerfield River	6/10 years[3]
Windsor	Connecticut River	Feb 1970,Mar 1975,Mar 1979
Wolcott	Lamoille River	Apr 1974
Woodstock	Ottauquechee River	Mar 1976

Footnotes:

[1] Information furnished by State Civil Defense
[2] Information furnished by Local Civil Defense Director
[3] Information furnished by Town Official

IV. ICE JAM FORMATION

Ice jams usually occur during the late winter season, although New England has experienced ice jams as early as December and January when unseasonably warm weather coupled with heavy rains have caused ice jams and flooding.

There are two processes which are responsible for the breakup of a solid ice cover, first a gradual deterioration of the ice strength occurs in the spring when higher sun angles and warmer air temperatures melt snow from the surface. This leaves a layer of water on the ice surface which absorbs more solar radiation which in turn causes subsequent melt along the ice crystal boundaries. If not disturbed by other forces, the ice will melt in place.

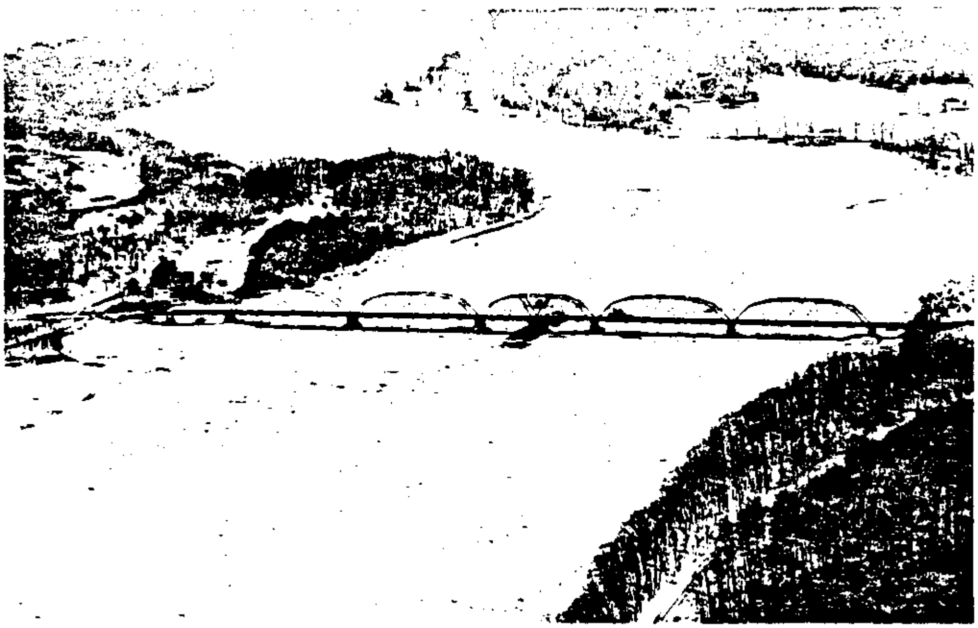
In rivers, however, the current flow beneath the ice is a second factor. In fact this condition is responsible for midwinter ice breakups that can lead to the most destructive ice jams. Any increase in streamflow will raise the ice level and break the ice loose from the shore. If the river discharge stays high due to rain or snowmelt in the upstream areas of the watershed, the higher flow will move the ice downstream. As it moves, the ice breaks up. The size of the ice floes depends on the extent of the strength deterioration and the distance the floes move. As might be expected, the ice in those reaches with steeper slopes and higher current velocities will break up first.

When the moving ice hits the fixed ice in a slow, flat reach it may break up the stationary ice and carry it along, or a jam may form. It is also possible for jams to form without ever running into stationary ice. When stream velocity decreases, the larger floes become grounded and as the blocks of ice begin to pile up, an ice jam is formed. When considering flooding problems and removal, ice jams occur in two basic forms, the simple jam and the dry jam. They are similar except that the first, the simple jam, allows a small amount of water to flow beneath the jam. The second type, the dry jam, occurs when the ice becomes grounded and thereby almost completely restricts streamflow. When considering action to relieve ice jam flooding most methods described in this report (see Section VII B "During Ice Jam Conditions") are applicable to the simple jam. In the case of a dry jam, the absence of flow beneath the jam prevents all methods except mechanical removal from being effective.

Predicting where an ice jam will occur is a difficult task. However, there are a number of typical locations where jams form. As mentioned above, a section of a river where the velocity decreases is a potential jam location. Decreases in velocity are found at the confluence of rivers and where streams have a low gradient. During freezeup the slower moving reaches freeze first, and so have a thicker ice cover at breakup. Another location might be a constriction in the stream channel, at an island or a bend, or at manmade features such as dams, bridge abutments and bridge piers (see Figure 1). A third typical location is a shallow reach where the ice has frozen to bottom boulders or shoals so that the ice cannot be lifted and moved by the increased waterflow.

Once the ice is stopped at any location the jam thickens rapidly, primarily by underturning of ice blocks. The net result is a very rapid constriction of the channel capacity and subsequent backing up of the upstream flows (see Figure 2).

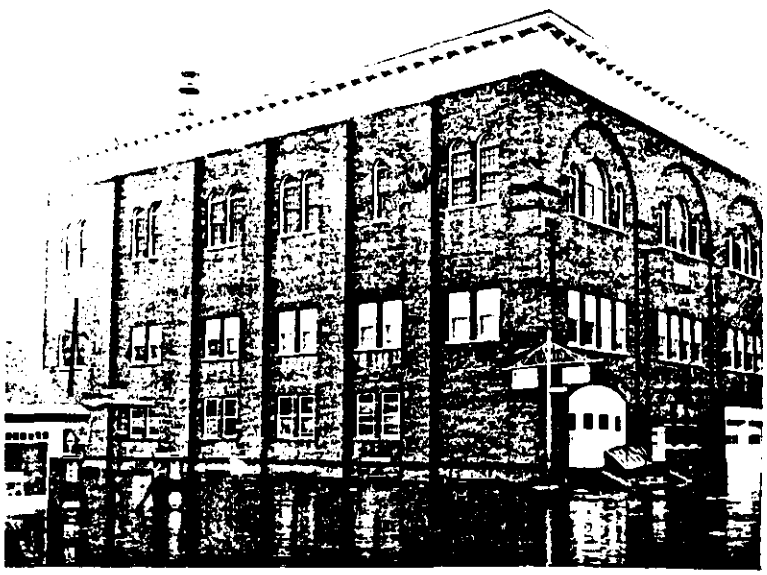
Chester, Vermont - Williams River, Jammed
ice downstream of Rout 103. (February 1976)



Richmond/Dresden, Maine - Kennebec River. Jammed ice at
Richmond/Dresden Bridge. (January 1978)

FIGURE 1

Gardiner, Maine - Cobbosseeconte Stream. Backwater flooding caused by an ice jam downstream on the Kennebec River. (January 1978)



Lancaster, New Hampshire - Israel River. Town Offices flooded by an ice jam on the Israel River. (March 1968)

FIGURE 2

V. EFFECTS OF ICE JAMS

Ice jams have a variety of effects. Backwater flooding caused by ice jams is the most noticeable because it usually affects many people in the community. However, ice jams often result in several other problems, causing erosion, physical damage to nearby structures, and stoppages in navigation. Although ice jams do result in all of these problems, the major concern of most northern New England communities is flooding.

1. Riverine Flooding. Riverine flooding results when either block ice jams or solid ice cover obstruct the natural flow of a stream, and create a damming effect which cause flooding to the area upstream of the ice jam. It should be noted that flooding is the result of obstructions to natural flow regardless of rainfall, although precipitation could seriously increase the degree of flooding. Flooding from an ice jam occurs very quickly. The situation is not like a normal free flow flood where the channel is not large enough for the flow. In the case of an ice jam the channel is blocked, and suddenly there is a dam in the river, albeit leaky and temporary, which creates a lake with no convenient spillway.

2. Erosion and Sedimentation. The formation of ice jams and their movements, similar to the movements of a glacier, have a scouring effect on both the streambed and streambank. When ice jams melt in place, most of the sediment picked up by the ice is deposited in the area where melting takes place. This sedimentation increases the possibility that an ice floe will become grounded at that site in the future.

3. Structural Damage to Hydraulic Structures. Because the static pressure of ice jams is often not considered in the design of hydraulic structures (bridges, dams, dikes, etc.), ice jams can cause severe structural damage to these structures.

4. Damage to Buildings, Roadways and Utilities. Blocks of ice, when suddenly released by the breakup of an ice jam can attain dangerously high velocities and cause serious damage to private and public properties.

5. Navigation. Ice jams or a solid ice cover can prevent or delay the passage of ships. While this is not a major problem in New England, it is a factor for some communities.

VI. HISTORICAL FLOODING

Ice jam flooding has always been a problem in New England. During one of New England's greatest recorded floods, the March 1936 flood, damages on many streams were greatly increased by ice jam flooding. In more recent times, severe ice jam flooding has occurred throughout Maine, New Hampshire and Vermont during the years of 1973, 1976, and 1978.

Since 1 January 1970, 249 communities in Maine, New Hampshire and Vermont (listed on Tables 1-3) have been affected by ice jam flooding. As illustrated on Plates 1-3, ice jams are a widespread problem and have occurred on nearly all major streams and many small streams throughout the three states. Of the 249 communities listed, 49 (see Plates 1-3) or 20 percent were identified as having frequent ice jam floods which caused substantial damage. In addition to these documented cases of ice jam flooding, it is expected that there are more communities which have been flooded by ice jams, but that these occurrences have not been documented.

Severe ice jam flooding in several of the 49 communities has resulted in detailed studies and construction of protection works at a number of locations by the Corps of Engineers. Work currently underway by the Corps includes:

1. An investigation of flooding (frequently caused by ice jams) on the Aroostook River in Maine as Part of the St. John River Basin study.

2. A study of ice jam flooding in Richford, Vermont.

3. Construction of an ice retention weir in Lancaster, New Hampshire.

Work concerning ice jam flooding which has been completed by the Corps includes:

1. Construction of an ice retention dam in Cherryfield, Maine.

2. Channel excavation of Stony Brook in Wilton, New Hampshire.

3. Channel excavation of the White River in Hartford, Vermont.

4. A study of ice jam flooding in Hardwick, Vermont.

5. Several reports on ice jams published by the Cold Regions Research and Engineering Laboratory.

With the exception of material obtained in the above investigations by the Corps, little written information is available for most ice jam floods. In the event of an ice jam, most of the effort is devoted to emergency flood fighting operations and consequently little effort has been expended recording specific damages caused by ice jams. It is therefore difficult to fully document past occurrences.

To avoid duplication of current Corps efforts, only those communities not presently under investigation (as listed above) were field visited. The purpose of these visits was to document past ice jam floods. The information on the 42 communities contained in Tables 4-6 represents the best information available to the study from contacts with Federal, State and local officials. Where data is missing in the tables, information simply was not available. Complete results of the interviews with local officials and plates showing the location of ice jams are contained in Appendices A, B, and C.

For each of the 42 communities, the approximate limits of the most significant ice jam flood occurring since 1 January 1970 have been delineated on the best topographic maps available. The usual location of the ice jam is also indicated on the map. This information can be utilized by individual communities, when developing plans of flood plain management. Many communities have no zoning regulations for flood plain development and the maps in this report may be used by those communities as an aid to regulating development of land within the ice jam flood plain. Communities which currently have flood plain zoning based on the 100-year flood plain may use the maps to develop more stringent regulations for areas commonly inundated by ice jams more frequently than the 100-year interval.

Communities may also use these maps to develop emergency plans for ice jam flooding. Access routes to the ice jam can be laid out in preparation for mechanical removal of the ice jam. Additionally, use of the maps in determining roadways commonly inundated will assist the community in developing a plan which will provide fire and ambulance service to residents, either by stationing apparatus at key areas, or evacuating residents who would otherwise be isolated from these services.

TABLE 4

SUMMARY OF MAINE INTERVIEWS

Community	Stream	Location of Jam	Dates of Flooding	Damages
Augusta	Kennebec River	1) Nehumkeag Island 2) Sandbar 1500′ Downstream of Former Route 226 Bridge. 3) Sandbar 2700′ Downstream of Former Route 226 Bridge. See Plate 9	Dec 1973 & Jan 1978 were most severe, ice jams have occurred in each of past 11 years.	1) Landslide on lower State Street and Gas House Hill, estimated damage: $110,000. 2) Washouts of several roads, estimated damage: $67,500. 3) Several public facilities flooded including: Marina Complex; Lithgow Library; City Hall; Post Office; and Civic Center. 4) Water Street business district flooded, approximately 27 structures affected. 5) Front Street business district and parking lot flooded, approximately 26 structures affected. 6) Homes on Kennedy Road and Howard Street were isolated. 7) One residence severely damaged, estimated damage: $12,500. 8) Total damage to private property estimated at close to $1 million.
Bethel	Androscoggin River	Hastings Island See Plate 4	Jan 1978 was most severe, ice jams occurred in 7 of past 10 years.	1) 12 unit trailer park affected. 2) 5-10 houses flooded. 3) One house lifted off foundation and carried downstream. 4) Railroad tracks flooded for length of 300 feet. 5) Lumber mill damaged. 6) Routes 2 & 26 closed for one day. 7) Route 2 bridge endangered. 8) Farmland inundated.

TABLE 4 (Cont.)

SUMMARY OF MAINE INTERVIEWS

Canton	Androscoggin River	Stevens Island See Plate 5	Jan 1978 most severe, ice jams have occurred in 3 of past 11 years.	1) Several acres of farmland flooded 2) 30 to 40 houses had a foot or more of water. 3) Underground gasoline storage tank on Route 108 was forced to surface. 4) Route 140, main road to Jay, closed for one day. 5) Ice within 3-4 feet of Route 140 bridge.
Chelsea	Kennebec River	1) Nehumkeag Island 2) Sandbar 1500′ down-stream of former Route 226 Bridge. 3. Sandbar 2700′ down-stream of former Route 226 Bridge. See Plates 8 and 9	Dec 1973 & Jan 1978 were most severe, ice jams have occurred in each of past 11 years.	1) Streambank erosion.
Dresden	Kennebec River	1) Little Swan Island 2) Richmond/Dresden Bridge See Plates 6 and 7	Feb 1970, Feb 1972 & Jan 1978 were most severe, jams have occurred in 5 of past 11 years.	1) One person evacuated. 2) Town isolated from other side of river- 12 mile detour. 3) One structure flooded 4) Streambank and farmland erosion 5) Portions of Route 128 closed.
Farmingdale	Kennebec River	1) Nehumkeag River 2) Sandbar 1500′ down-stream of former Route 226 Bridge. 3) Sandbar 2700′ down-stream of former Route 226 Bridge See Plates 8 and 9	Jan 1978 was most severe, ice jams have occurred in each of past 11 years.	1) One commercial structure on Route 201 flooded. 2) One house flooded and one person evacuated. 3) Route 201 closed, 2-1/2 mile detour for emergency vehicles. 4) Streambank erosion 5) Railroad tracks inundated.

TABLE 4 (Cont.)

SUMMARY OF MAINE INTERVIEWS

Farmington	Sandy River	Oxbow near sewage treatment plant. See Plate 14	Jan 1978 was most severe, ice jams have occurred in each of past 11 years.	1) Route 4-27 and Route 2 closed for several days--1 mile detour. 2) Ballpark, tennis courts flooded. 3) 8-12 Commercial bldgs flooded. 4) 20-25 Houses flooded. 5) University of Maine-Farmington athletic fields inundated. 6) Access road to sewage treatment plant impassable.
Gardiner	Kennebec River	1) Nehumkeag Island 2) Sandbar 1500′ downstream of former Route 226 Bridge. 3) Sandbar 2700′ downstream of former Route 226 Bridge. See Plates 7 and 8	Feb 1970, Dec 1973, & Jan 1978 were most severe, ice jams have occurred in each of past 11 years.	1) Route 24 closed to traffic for several days--1/2 mile detour. 2) Approximately 100-125 structures in business district affected. 3) 800,000 gallon gas tank was lifted and floated downstream.
Hallowell	Kennebec River	1) Nehumkeag Island 2) Sandbar 1500′ downstream of former Route 226 Bridge. 3) Sandbar 2700′ downstream of former Route 226 Bridge. See Plate 9	Dec 1973 & Jan 1978 were most severe, ice jams have occurred in each of past 10 years.	1) Route 201 closed to traffic. 2) Commercial and residential structures on Front St. inundated. 3) 80-100 structures on Water St. affected. 4) Water backs up through sewer system.

TABLE 4 (Cont.)

SUMMARY OF MAINE INTERVIEWS

Howland	Piscataquis River	1) Dam at confluence with Penobscot River See Plate 10 2) Lowell Island See Plate 11	Jan 1978 was most severe, ice jams have occurred in each of past 11 years.	1) Electrical power lines downed. 2) Trailer park, 35-50 trailers flooded. 3) 20-30 residences in Howland Center flooded. 4) *Basement flooding at Town Offices.* 5) Water Street closed. 6) Route 116 closed.
Maxfield	Piscataquis River	Gravel bar at Medford/ Maxfield town line. See Plate 12	Jan 1978 was most severe, ice jams have occurred in each of past 11 years.	1) Route 16 closed. 2) Streambank erosion. 3) One family evacuated.
Medford	Piscataquis River	Schoodic Point See Plate 12	Jan 1978 was most severe, ice jams have occurred in each of past 11 years.	1) Streambank erosion. 2) Route 16 closed. 3) Farmland flooded.
Milo	Pleasant River	Oxbow 1/2 mile downstream of Route 16 Bridge. See Plate 13	Jan 1978 was most severe, ice jams have occurred in each of past 11 years.	1) Two homes flooded. 2) Route 16 closed. 3) Roadway washouts. 4) Route 16 bridge threatened, ice to roadway surface. 5) Farmland inundated.
Pittston	Kennebec River	1) Little Swan Island 2) Richmond/Dresden Bridge 3) Nehumkeag Island See Plates 7 and 8	Feb 1970, Feb 1972, & Jan 1978 were most severe, ice jams have occurred in 5 of past 11 years.	1) Streambank erosion.

TABLE 4 (Cont.)

SUMMARY OF MAINE INTERVIEWS

Randolph	Kennebec River	1) Nehumkeag Island 2) Sandbar 1500′ downstream of former Route 226 Bridge. 3) Sandbar 2700′ downstream of former Route 226 Bridge. See Plate 8	Feb 1970, Dec 1973 & Jan 1978 were most severe, ice jams have occurred in each of past 11 years.	1) Two commercial structures flooded. 2) Streambank erosion.
Richmond	Kennebec River	1) Little Swan Island 2) Richmond/Dresden Bridge. See Plates 6 and 7	Feb 1970, Feb 1972 & Jan 1978 were most severe, ice jams have occurred in 5 of past 11 years.	1) Richmond/Dresden Bridge damaged. 2) Town of Dresden is isolated by closing of bridge. 3) One commercial structure flooded. 4) Farmland flooded.

TABLE 5

SUMMARY OF NEW HAMPSHIRE INTERVIEWS

Community	Stream	Location of Ice Jam	Dates of Flooding	Damages
Allenstown/ Pembroke	Suncook River	1) Abandoned dam 400´ downstream of Route 28 2) Oxbow 1-1/2 miles upstream of Route 3 Bridge 3) Webster Dam See Plate 24	March 1977 was worst ice jam. Ice jams have occurred 8 times since 1970.	1) a. 5 Homes flooded b. 50 trailers flooded c. Old Buck Road inundated 2) a. 62 homes flooded 40 families evacuated. b. 10 mobile homes flooded, 10 families evacuated 3) a. 8 multiple residence houses flooded b. Buck Street flooded
North Conway	Saco River	Sandbars and oxbows between North Conway pumping station #2 and Mill Brook See Plate 21	February 1973 and March 1977 were most notable, but jams have occurred 9 out of 11 years	1) Farmland inundated 2) No access to pumping station #2 (station is floodproofed)
Franconia	Gale River	1) Bend in river 500´ downstream of Route 18 Bridge	March 197 and February 1973 were worst ice jams. Ice jams have occurred 9 times since 1970	1) 6 families isolated 2) a. 5 homes flooded b. 2 commercial structures c. Route 18 closed
Franconia-Sugar Hill		2) Bend in river downstream of Littleton National Bank		3) a. 2 homes flooded b. 1 home isolated b. Erosion to farmland d. Roadway inundated
Sugar Hill		3. Bend in river 500´ downstream of private bridge near Hannah farmhouse See Plate 19		

TABLE 5 (Cont.)

SUMMARY OF NEW HAMPSHIRE INTERVIEWS

Henniker	Contoocook River	1) Abutments of abandoned railroad bridge 1 mile upstream of center of town 2) Bridge over Contoocook in center of town See Plate 17	March 1977 was worst ice jam. Ice jams have occurred 9 times since 1970.	1) Contoocook Valley Paper Mill flooded 2) a. 2 homes flooded b. 1 commercial structure flooded c. Possible damage to bridge
Lebanon	Connecticut River	1) Bend in river downstream of Route 89 Bridge 2) Sandbar at mouth of Mascoma River See Plate 27	February 1970 was worst ice jam. Ice jams have occurred in 10 of past 11 years	1) Sewer pipeline damaged, raw sewage discharged into Connecticut River (January 1976). 2) 2 shipping plazas threatened
Lisbon	Ammonoosuc River	1) Dam upstream of School St. Bridge See Plate 15	March 1978 was most severe, but has occurred 9 of last 11 years	1) Historic school house moved off foundation 2) 3-4 families evacuated 3) 5 commercial buildings flooded 4) Fields flooded, eroded 5) Approximately 300 feet railway washed out 6) Main thoroughfare, Route 302, closed for 2 days 7) Potential for structural damage to School Street Bridge

TABLE 5 (Cont.)

SUMMARY OF NEW HAMPSHIRE INTERVIEWS

Merrimack	Souhegan River	1) Oxbow 8000′ upstream of Everett Turnpike Bridge	March 1977 was worst ice jam. Ice jams have occurred 9 times since 1970.	1) 5 homes flooded
	Baboosic Brook	2) Twin Bridge Road Bridge		2) a. Bridge closed causing 3 mile detour b. Damage to bridge, estimated at $80,000 to replace
		3) Oxbow 1/2 mile upstream of Everett Turnpike Bridge See Plate 23		3. New Bedford Road closed, causing 3 mile detour
Milford	Souhegan River	1) Dam in center of Milford 2) Sharp bend near drive-in theater See Plate 22	January 1978 was worst ice jam. Ice jams have occurred in 10 of past 11 years	1) Mobile home park inundated 2) 2 commercial structures flooded
Peterborough	Contoocook River	1) Bridge at Sharon Road near Harris Sand Mill 2) Dam 150′ upstream of Main Street Bridge 3) Old North Dam See Plate 18	Ice jams of nearly equal intensity have occurred in each of the past 11 years	1) a. 1 mill flooded b. 2 homes flooded-evacuated 2) 5-8 structures housing 10-15 businesses flooded 3) 1 motel flooded
	Nubanusit Brook	Confluence of Nubanusit Brook with Contoocook River See Plate 18		1) Same as 2) above

TABLE 5 (Cont.)

SUMMARY OF NEW HAMPSHIRE INTERVIEWS

Plymouth	Baker River	Several jams form at various sandbars between confluence with Pemigewasset and Smith Road Bridge See Plate 20	February 1973, January 1976 and March 1977 were most severe, but jams are an annual event	1) 2-3 houses flooded 2) Ice within 3-4´ of covered bridge at Smith Road - potential for damage to bridge 3) Fairgrounds flooded 4) 2 commercial buildings flooded 5) Sales lot with approximately 40 trailers flooded 6) Town water supply at Foster Street endangered with 3-4´ water over well field 7) Loon Lake and Fairgrounds Roads flooded in spots, isolating 3-4 houes
Plymouth-Holderness	Pemigewasset River	Jams form at three locations 1) Sandbar near Ashland Golf course 2) Sandbar approximately 1/4 downstream from bridge 3) Sandbar at Baker River See Plate 20	Same as above	1) Ice hits low street of Bridge Street bridge, endangering bridge 2) Over 30 homes evacuated in Holderness, water 3-4´ deep in most first floors 3) Approxmately 12 commercial buildings in Holderness flooded 4) Plymouth State College floodproofed, but surrounded by water 5) Bridge Street closed, 12 mile detour for emergency vehicles
Stratford	Connecticut River	Bend in river, 3000´ downstream of Bloomfield, VT-North Stratford, NH bridge See Plate 16	March 1979 was most severe, however ice jams have occurred in 5 of past 11 years	1) Total damage estimated at $3-4 million 2) 120 households flooded a. 14 destroyed b. 25 suffered major damage c. 81 suffered minor damage 3) 1 paper mill flooded 4) Route 3 closed 5) Railroad track washed out

TABLE 6

SUMMARY OF VERMONT INTERVIEWS

Community	Stream	Location of Jam	Dates of Flooding	Damages
Brattleboro	Whetstone Brook	1) Near Country Drive Bridge 2) at Railroad bridge near confluence with Connecticut River See Plate 35	January 1976 and March 1973 were most significant 5 out of past 10 years ice jams formed	1) Several businesses on Route 9 were flooded 2) Route 9 closed to traffic 3) Mountain Home Mobile Home Park, 20 trailers affected by flooding 4) 200 people evacuated; 5) $2000 expense to town for: crane; backhoe; and labor costs.
Cambridge	Lamoille River	Bend in river 1200′ downstream of Route 15 bridge See Plate 31	February 1976 was worst ice jam. Ice jams have occurred 9 times since 1970	1) 12 homes flooded 2) 1 commercial building flooded 3) 1 recreational building flooded 4) Route 15 closed, isolating 30 homes 5) Farmland flooded
Cambridge/ Jeffersonville	Brewster River	Route 15 bridge See Plate 31	February 1976	1) 15 homes flooded 2) Tennis camp flooded
Cavendish	Black River	1) Island 600 feet downstream of Gulf Road Bridge 2) Abandoned dam 3,000 feet upstream of Gulf Road Bridge 3) Railroad bridge piers at intersection of Routes 103 & 131. See Plate 25	February 1976 flood was most significant, but ice jams are an annual event.	1) Two residences flooded. 2) Hydroelectric station operations impaired. Flashboards damaged. 3) Potential damage to Gulf Road Bridge 4) Bank erosion along Route 103.

TABLE 6 (cont)

SUMMARY OF VERMONT INTERVIEWS

Chester	Williams River	1) Farm crossing (near Jewett Road 2) 1 mile north of Gassetts near Route 103 Bridge See Plate 38	February 1976 was most notable Ice jams occur annually.	1) Bridge on Joe Swett Road washed out ($70,000 replacement cost) 2) 3 residences isolated on Jewett and Thompson Roads 3) Route 103 closed causing a 20 mile detour 4) Streambank erosion 5) Municipal sewer line threatened on South Branch
	Middle Branch William River	1) Joe Swett Road Bridge		
	South Branch Williams River	1) Confluence of South Branch with Middle Branch Williams River 2) Route 103 Bridge See Plate 37		
Hartford	Connecticut River	1) Bend in river downstream of Route 89 bridge 2) Gravel bar at mouth of Mascoma River See Plate 27	February 1970 was worst ice jam. Ice jams have occurred in 10 of past 11 years	1) 4 homes flooded 2) 2 commercial structures flooded 3) Reduced efficiency of power generation at Wilder Dam
	Ottauquechee River	1) Abandoned dam near River Street Bridge See Plate 28	Same as above	1) 2 homes flooded
Ludlow	Black River	Gravel bar downstream of sewage treatment plant See Plate 26	February 1976 and March 1973 were significant ice jam. Ice jams have occurred 3 times since 1970.	1) trailer park and factory threatened

TABLE 6 (cont)

SUMMARY OF VERMONT INTERVIEWS

Lyndon	1) Sheldon Brook	Confluence of Sheldon Brook with the Passumpsic River	December 1973 and February 1976 were most significant. Ice jams have occurred in 7 of past 10 years.	1)a. Open fields flooded b. State Aid #2 closed resulting in 2 mile detour to Red Village
	2) West Branch Passumpsic River	Route 5 bridge	Same as above	2) 1 home flooded
	3) Miller Run	State Aid #26 bridge	Same as above	3) 4 homes flooded
	4) Branch Brook	State Aid #1 bridge	Same as above	4)a. 6 homes flooded b. York Street Bridge closed c. Historic covered bridge damaged
	5) Passumpsic River	Lyndonville Electric Light and Power Company Dam	Same as above	5) 1 commercial building flooded
	6) Passumpsic River	Route 5 bridge	Same as above	6) Motel flooded
	7) Passumpsic River	Sandbar downstream of Route 122 bridge	Same as above	7)a. Meadow land flooded b. 7 homes flooded c. Route 122 impassible
	8) Passumpsic River	Bend in river, 500´ upstream of Miller Run See Plate 34		8)a. 50 mobile homes flooded b. 7 houses flooded c. 3 commercial buildings flooded d. Routes 114 and 5 impassible
Rochester	White River	1) Oxbow 4500´ downstream of Liberty Hill bridge 2) Bridge to Mount Reeder 3) Private bridge 1/2 mile upstream of town 4) Route 100 Bridge See Plate 36	February 1976 was worst ice jam, but ice has jammed in each of the past 11 years	1) $20,000 damage to 1 farm 2) 12 Liberty Hill families isolated 3) 12 Mount Reeder families isolated

TABLE 6 (cont)

SUMMARY OF VERMONT INTERVIEWS

Stowe	Little River	1) Bend in river, 1500 feet upstream of dam in Moscow 2) Bend in river, 2,000 feet downstream of canoe factory See Plate 32	March 1976 was worst ice jam. Ice jams have occurred 3 times since 1970.	1) Open fields flooded 2) Factory flooded
Tunbridge	First Branch White River	1) Oxbow 1-1/2 miles downstream of Tunbridge Fairgrounds	February 1976 was worst ice jam. Ice jams have occurred 8 times since 1970	1) Fairgrounds flooded 2) Covered bridge damaged 3) Open fields flooded, erosion of farmland
		2) Bend in river just upstream of Tunbridge Fairgrounds		1) Covered bridge da-aged 2) Basements flooded
		3) Abandoned dam 1-1/2 miles upstream of North Tunbridge See Plate 30		1) Basements flooded 2) Route 110 closed, isolating 25 families
Wilmington	North Branch Deerfield River	1) Bend in river near Route 100 bridge 2) Gravel bar behind Ploghman's Rest Lounge 3) Confluence of Beaver Brook 4) 2 channel constrictions downstream of Beaver Brook See Plate 33	February 1973 was worst ice jam. Ice Jams have occurred 9 times since 1970	1) Total damage estimated at $40,000 2) Library flooded 3) Fire station flooded 4) Town offices flooded 5) 6 homes flooded 6) 7 commercial structures flooded 7) Wheeler Flats inundated 8) Route 100 closed 9) Route 9 closed 10) Highley Hill Road Bridge flooded 11) Baseball fields and tennis courts flooded
Windsor	Connecticut River	1) Sandbar 1500' upstream of Windsor Airfield 2) Sandbar near Horseback Ridge 3) Chase Island See Plate 29	February 1970, February 1973 and March 1979	1) 6-8 homes flooded 2) Shopping plaza inundated 3) Town sewage treatment plant inundated 4) Route 5 closed

VII ACTIONS TO PREVENT ICE JAM FLOODING DAMAGES

Actions for dealing with the impact of ice jam flooding can be initiated during either pre or post flooding conditions. Of course, all actions which prècede the actual event have the benefit of avoiding damages and the emergency operations which accompany the flooding. In the following paragraphs possible techniques which can be employed in pre and post ice jam conditions are discussed and various authorities of the Corps of Engineers which may be of aid to the State and community are presented.

A. Pre - Ice Jam Conditions

There are several options available to State and local officials in the prevention of damages due to ice jam flooding. These include: flood plain management; development of emergency plans; ice retention structures, channel improvements; dusting; floodwall; and flood insurance.

1. Flood Plain Management

Having identified areas subject to ice jam flooding, the local community may choose to adopt specific flood plain regulations which consider the threat of ice jam flooding, recognizing that ice jam flooding can be much more frequent and in some events can exceed projected 100-year flood elevations which are the most common data used in flood plain regulations. As a result, many current flood plain regulations do not account for the effects of ice jam flooding. This could prove to be a serious oversight as development continues in the various communities and residential or other type properties are constructed in the area outside of the presently zoned flood plain but inside the area frequently affected by ice jam flooding. This could lead to unnecessary economic and social burdens for the unsuspecting families or businesses who believe they are safe from floods. The identification of areas subject to the effects of ice jams and adoption of regulations for these areas would prevent these hardships. Since many of the study area municipalities will shortly enter the regular phase of the National Flood Insurance Program (NFIP) this appears to be a good time to incorporate the ice jam affected flood plain into the regulations required by that program.

The primary objective of such regulations would be to promote wise use of the flood plain and reduce flood losses to the community. The principal flood plain regulatory tools at the local level include zoning, subdivision controls and building codes.

Typical Regulations

a. Zoning. Zoning is the most popular local flood plain management tool. Traditional zoning divides a community into districts and applies varying use standards to each of the districts. A zoning ordinance consists of (1) a map which delineates use districts and (2) a written text which establishes use standards for the districts. Flood plain zoning maps and textual provisions are often part of a broader zoning ordinance. One or more flood plain districts are usually delineated on the community zoning map delineating many other zones. A single district approach tightly controlling all development within the delineated flood plain has been adopted for many rural communities and a lesser number of urban areas on an interim or long-time basis.

b. Subdivision regulations: Subdivision regulations control the division and sale of lands. Subdivision standards related to flooding typically require that lots be made suitable for their intended uses, and that the subdivider install public facilities such as roads, sewers, and water with protection from flooding.

c. Building and housing codes: Building and housing codes regulate building design and construction materials. They are less frequently used in flood plain management, but they can be modified to insure that new construction is better suited to withstand flooding.

Flood plain regulatory efforts are often hampered by limited public perception of problems and inadequate data. This is especially true of flood plain regulations for ice jam flooding. For this reason, single-district prohibitory ordinances are often required. These may be initially based upon historic flood maps or high water marks. With a single district, special permit approach, more specific flood data are often gathered on a case-by-case basis through special permit procedures as individual flood plain developments are proposed. Case-by-case data gathering necessary for a single-district approach may be difficult for many communities lacking technical expertise. This problem is less serious if consultants are available and the principal burden of data generating is shifted to the developer. In the case of subdivisions, it is easier to shift the data gathering burden to the subdivider than to the individual lot owner, since the subdivider may be able to carry out hydrologic and hydraulic studies in conjunction with more traditional land surveys and can pass the costs of these studies on to the purchasers. If private consultants are to be employed by developers, local officials should be certain that the consultants are capable of producing accurate flood data. Additional possible sources for the development of flood data include the State and the Federal Emergency Management Agency as part of the National Flood Insurance Program.

2. Emergency Plans

As described in the interview portion of Appendices A - C, many communities have plans for dealing with the effects of flooding including those caused by ice jams. The following paragraphs therefore, are intended as a brief checklist of common elements in such plans. A more complete checklist can be found in "Guide for Flood and Flash Flood Preparedness Planning" prepared by the National Weather Service (NWS) and its use by the towns is recommended.

Overall, all preparedness plans for dealing with flooding should include the following:

* A system for early recognition and evaluation of potential floods.

* Procedures for issuance and dissemination of a flood warning.

* Arrangements for temporary evacuation of people and property.

* Provisions for installation of temporary protective measures.

* A means to maintain vital services.

* A plan for post-flood reoccupation and economic recovery of the flooded area.

Flood warning is the critical link between forecast and response. An effective warning process will communicate the current and projected flood threat, reach all persons affected, account for the activities of the community at the time of the threat (day, night, weekday, weekend), and motivate persons to action. The decision to warn must be made by responsible agencies and officials in a competent manner to maintain credibility of future warnings.

An effective warning needs to be followed by an effective response. This means effective and orderly evacuation of people and property. Actions which can facilitate this include:

* Establishment of rescue, medical and fire squads

* Identification of rescue and emergency equipment which can be utilized during a flood

* Identification of priorities for evacuation.

* Surveillance of evacuation to insure safety and protect property.

In addition to evacuation, property can be protected by various protection measures. These include: temporary flood proofing of structures, use of pumps, and flood fighting. Flood fighting includes such actions as raising the level of existing protection, closing highways, streets and railroads, prevention of backwater in sewers, and protection against erosion. All of these actions contribute to the overall goal of reducing flood loss.

In addition, a forecast, warning, and evacuation strategy will include telephone, energy (gas and electric), sewage, water, traffic control, hospitals, as well as police and fire services. Post-flood reoccupation and recovery includes:

* Reestablishment of conditions which will not endanger public health: disease and insect control, safe drinking water, safe sewage disposal, medical supplies

* Return of other vital services

* Removal of sediment, debris, flood fighting equipment and materials

* Repair of damaged structures

* Establishment of disaster assistance centers for financial and other assistance.

3. Ice retention and diversion structures.

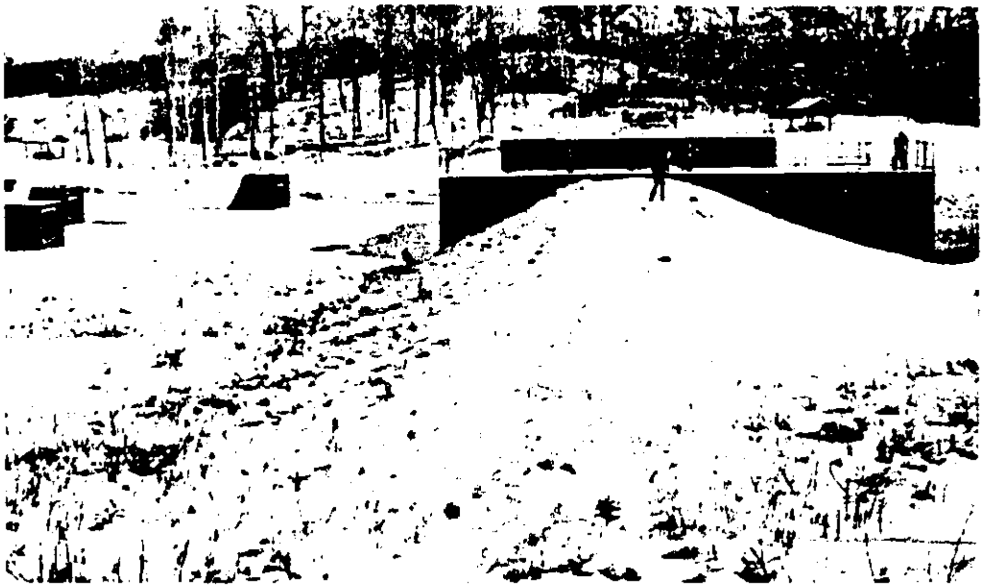
Ice booms and control structures are designed to collect and hold ice at non-critical areas before it can jam downstream and cause serious flooding in high damage areas. Diversion channels allow ice jams to form, but divert floodwaters away from damage sites. Although dikes do not directly solve the problem of ice jams, they are commonly employed to combat flooding caused by ice jams. These structural solutions are expensive and cost efficient at only a few sites in New England. Studies which include examining structural solutions for recurrent ice jams are currently underway by the Corps of Engineers for the towns of Richford, Vermont and along the Aroostook River in Maine. A project is under construction in Lancaster, New Hampshire and there is a completed project in Cherryfield, Maine (See figure 3).

4. Channel Improvements:

Constrictions, shallow streambeds and sharp bends in the stream are potential locations of ice jams. Corrective measures include the removal of obstructions and clearing debris from streambanks. Larger and more expensive undertakings are the deepening of the channel and the straightening of the stream. This type of major work should be carefully considered before it is undertaken. The Corps has completed channel improvements at Wilton, New Hampshire and Hartford and Richford, Vermont to prevent the formation of ice jams.

5. Dusting:

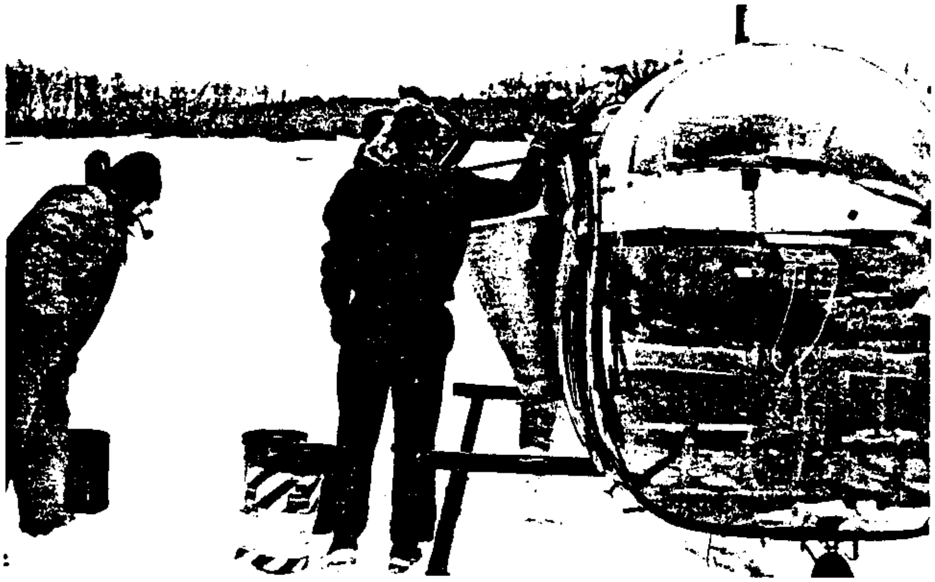
Dusting refers to the spreading of a dark substance on an ice surface. The principle behind this method is that the dark material attracts and retains the sun's heat and therefore, increases the melting rate of the ice. This technique is more of a preventive measure than a solution to actual ice jams. Dusting is usually only effective on river sheet ice as a safeguard against the formation of ice jams in the future (see figure 4). A disadvantage of dusting is that narrow or sinuous streams are not easily covered aerially. A second problem is weather, cloudy weather slows down the melting process and even a slight dusting of snow will almost entirely negate the dusting effort.



Cherryfield, Maine - Narraguagus River.Corps of Engineers Ice Retention Dam constructed in 1961.

Cherryfield, Maine - Narraguagus River. View from downstream. The 3 piers prevent ice floes from moving downstream.

FIGURE 3



Farmington, Maine - Sandy River. Crew prepares helicopter for dusting run. (April 1970)

Farmington, Maine - Sandy River. Several days after dusting, the solid ice cover has melted. (April 1970)

FIGURE 4

Additionally, caution should be used in the choice of dusting material. Although any dark substance can be effective, some materials may be environmentally unsuitable for deposit in the river. State environmental officals should be consulted before dusting. Dusting is an effective and relatively cheap method of preventing ice jams and it is recommended that it be implemented as a precautionary measure, especially in areas known to be prone to ice jam flooding.

6. Flood Insurance

Flood insurance does not actually prevent flood damages, however it can provide protection for the home and business owner from the financial losses associated with the flooding.

Although not addressed in earlier flood insurance studies published by the Federal Emergency Management Agency (FEMA), the more recent studies are considering the effects of ice jam flooding where applicable. Residents of communities which are participating in the National Flood Insurance Program (NFIP) may wish to investigate the types of coverage available.

B. <u>During Ice Jam Conditions</u>

When an ice jam occurs, there are few alternative actions for the community. They can allow the jam to remain in place and use conventional flood fighting techniques including sandbagging, use of pumps and evacuation of flooded areas, or they can remove or break up the jam (See figure 5). Methods of removing or breaking up the jam include physical removal of the ice, blasting the jam, using surges of water to break up the jam and the use of ice breakers.

1. Mechanical removal.

The use of construction equipment is usually the first remedial action taken in an ice jam. In the case of an ice jam forming at a bridge, heavy equipment such as a backhoe or dragline and physically removing the blocks of ice from the river is probably the safest and surest method of relieving ice jam flooding. When the ice jam is located in an area not readily accessible to construction equipment, mechanical removal is somewhat more complicated. The major obstacle is access. During ice jam season, it is likely that there will be a snow cover on the ground and therefore, it is advisable that aerial photography or current mapping be used to prevent damage to utilities and private property as well as prevent damage to the equipment itself because of hazardous terrain. Mechanical removal, while relatively safe, is slow and expensive, but is the recommended first step in the case of an ice jam. (See figures 5 and 6.)

2. Blasting.

Surface explosives: Use of surface explosives is generally an effective method of mitigating flooding caused by ice jams. Blasting is a dangerous operation and all other methods should be exhausted before it is undertaken. Residents familiar with the particular stream and its history should be consulted to determine how great a hazard exists. Before considering explosives, the area downstream of the ice jam should be checked to insure that release of ice and water will not have an adverse effect downstream. Additionally, there must be enough water present to carry the loosened ice downstream. If the flow has dropped, or has moved into another channel, blasting should not be considered. Once it has been decided to blast, an expert certified by the State should be employed to do the actual work. Any type of explosive can be used but if possible it is recommended that ANFO be used. ANFO is a mixture of ammonium nitrate fertilizer and fuel oil. It must be kept relatively dry and therefore, the charge should be wrapped in plastic. ANFO is recommended because of its low cost and safety factors. A large booster charge must be used to detonate ANFO and therefore, placement is relatively safe. Additionally, because ANFO must be kept dry, if a misfire does occur, the mixture will eventually dissolve and lose its blasting power and therefore, no live charges will be left in the river.

The proper procedures is to start at the head of the jam, boring holes through the ice and placing charges beneath the ice (see figure 7). Once the jam has been loosened, the stream should be allowed to do the work of moving the ice downstream (see figure 8), and blasting should be stopped. Blasting is an emergency operation and should only be undertaken to relieve flooding. Once flooding has subsided, blasting should be abandoned. Additionally, explosives may have an adverse effect on the environment and State environmental officials should be consulted before using explosives.

3. Surging:

Surging, caused by the opening or closing of a gate at a control structure, is an abrupt change in the discharge of a river. A surge in discharge increases velocities and stage and subsequently dislodges jammed ice. The sudden force of the water is also effective in breaking solid ice covers. There are not many sites in New England where control structures are available to attempt surging. An additional problem with surging is that abnormal releases of water can directly result in flooding and therefore the solution to the ice jam may cause more severe flooding than the ice jam itself. It is recommended that careful consideration be given to the effects of surging before it is attempted.

4. Ice breakers:

Due to channel depths of most streams and a lack of necessary ships, ice breakers have been used on a limited basis in New England. Ice breakers are most effective when breaking sheet ice and their capability in breaking jammed ice is suspect. The use of ice breakers is a slow, expensive process and other options should be explored before employing ice breakers (see figure 9).

Farmington, Maine - Sandy River. Sand bags are used to protect a temporary roadway. (April 1970)

Chester, Vermont - South Branch Williams River. Shoveldozer clears ice jam downstream of Route 103. (February 1976)

FIGURE 5

Lyndon, Vermont - Branch Brook. Dragline removes jammed ice, (February 1976)

Chester, Vermont - Williams River.
Dragline removes jammed ice downstream of Route 103 - see figure 1. (February 1976)

FIGURE 6

Hartford, Vermont - Connecticut River. Holes drilled in ice for the placement of charges. (March 1970)

Placement of charges below the ice cover.

FIGURE 7

Hartford, Vermont - Connecticut River. Detonation of a line of explosives.

Broken ice moving downstream after explosion.

FIGURE 8

Richmond, Maine - Kennebec River. Coast Guard ice breaker breaking solid ice cover. (February 1970)

Richmond, Maine - Kennebec River. Coast Guard ice breakers breaking ice at Richmond/Dresden Bridge. (February 1970)

FIGURE 9

VIII. AUTHORITIES AVAILABLE TO THE CORPS OF ENGINEERS TO AID IN PREVENTING DAMAGES FROM ICE JAMS

In addition to large projects which must be specifically authorized by Congress, the Corps of Engineers can carry out small project and emergency work under special continuing authorities which can aid in the prevention or combating of ice jam flooding

A. Emergency Operations

Public Law 84-99 (Emergency Flood Control Work) authorized an emergency fund to be expended at the discretion of the Chief of Engineers for flood emergency preparation, flood fighting and rescue operations and repair or restoration of flood control works threatened, damaged or destroyed by flood.

The Corps policy is that removal of ice jams that are not causing significant flooding or which do not pose an immediate serious threat of flooding is a local responsibility, although technical advice can be provided under Public Law 99. If the ice jam is actually causing severe flooding and constitutes a threat to public health and safety the Division Engineer has the authority to expend up to $100,000 to effect immediate measures to alleviate the flooding, subject to the following conditions:

a. The request for Corps' assistance must be made by a responsible State official (usually a letter from the Governor).

b. Available State and local capabilities have been depleted.

c. Corps work is supplemental to State and local efforts.

d. Local officials must furnish access rights and hold and save releases to the Government

e. The flood fight will be terminated by the Corps as soon as the flooding has stopped and the stream returned within its banks.

If the ice jam poses a serious and immediate flood threat to public health and safety, but is not yet causing actual flooding, its removal under Public Law 99 requires prior authority and funding from the Office of the Chief of Engineers, Washington, D.C., subject to the following additional conditions:

a. Prediction by the U.S. Weather Bureau of further adverse weather conditions increasing the threat of imminent flooding.

b. The work will be of an emergency type and subject to a timely completion.

c. The work must have a favorable benefit/cost ratio.

Public Law 79-256 (Section 14 of the 1946 Flood Control Act) as amended authorizes the Corps of Engineers to expend up to $250,000 for emergency bank protection measures at any single locality to prevent flood damage to public buildings, highways, water supply and sewage treatment works and non-profit public services.

Work under this authority shall serve to prevent damage to endangered highways, public works and essential public services for the general public which are endangered by reason of bank erosion in the immediate vicinity thereof. "Public Works" within the meaning of the above cited legislation are considered to be those essential facilities which serve the general public and are owned and operated by the Federal, State or local government, such as municipal water supply systems and sewage disposal plants. In addition to major highway systems of national importance, eligible highways may also include principal highways, streets, and roads of significant, importance to the local community, such as arterial streets, important access routes to other communities and adjacent settlements as well as roads designated as primary farm to market roads.

A project is adopted under Section 14 only after full detailed investigation and study clearly shows the engineering feasibility and economic justification of the proposed project. An investigation of a prospective project under Section 14 may be initiated after receipt of a formal request from a prospective sponsoring agency fully enpowered under State law to provide all required local cooperation. This request is made directly to the Division Engineer.

B. Small Projects

The Chief of Engineers under the direction of the Secretary of the Army, may authorize small projects which are complete in themselves and do not require additional Federal improvement to insure successful operation.

Two special continuing authorities are available which may be employed to combat ice jam flooding these are:

Section 205 of the 1948 Flood Control Act, as amended by Section 61 of the 1974 Water Resources Development Act provides authority to the Chief of Engineers to construct small flood control projects that have not already been specifically authorized by Congress. Each project selected must be complete-within-itself and be economically justified. In addition, each project is limited to a Federal cost of not more than $2 million, except where the project area has been declared a major disaster area during the five year period preceding the authorization date in which case the Federal cost limit would be $3 million. This Federal cost limitation includes all project related costs for investigations, inspections, engineering, preparation of plans and specifications, supervision, and administration, and construction.

Section 208 of the 1954 Flood Control Act (P.L. 780, 83rd Congress) as amended by Section 26 of the 1974 Water Resources Development Act, authorizes clearing and straightening of stream channels and the removal of accumulated snags and other debris in the interest of flood control. Each project selected must be economically justified. The maximum Federal expenditure per project is limited to $250,000. A Section 208 project is designed to be complete in itself and not require additional work for effective flood control.

Projects are adopted under Sections 205 and 208 only after full detailed investigation and study clearly shows the engineering feasibility and economic justification of the project proposed. An investigation of a prospective small project or snagging or clearing project may be initiated after receipt of a formal request from a prospective sponsoring agency fully enpowered under State law to provide all required local cooperation. This request should be made directly to the Division Engineer.

The provisions of Sections 205 and 208 have been used extensively in New England to combat the effects of ice jam flooding. Examples of applications of these authorities follows.

C. Current Corps Projects and Studies

Maine

Cherryfield:

Under Section 205, Cherryfield Dam (see figure 3), located on the Narraguagus River in Cherryfield, Maine was completed in 1961. The dam creates an artificial lake to hold sheet ice upstream. The reservoir is designed to hold the ice until it decays in the spring or release it after the ice in the downstream tidal waters between Cherryfield and Millbridge breaks up.

New Hampshire

Wilton:

Under Section 208, Wilton Local Protection Project, a channel excavation project was completed late in 1971 along 1,000 feet of Stony Brook to prevent ice jam flooding in Wilton.

Lancaster:

Under Section 205, a project is underway on the Israel River in Lancaster. A low ice retention weir located upstream of the Mechanic Street Bridge is under construction to provide local relief from ice jam flooding.

Vermont

Hartford:

Under Section 205, this small local protection project was completed in 1970. It provides channel improvements for the 2 mile reach of the White River immediately upstream of its confluence with the Connecticut River in the eastern part of Hartford.

Montpelier:

Under Section 208. In January 1978 large ice jams existed at two locations along the Winooski River between Montpelier and Middlesex, Vermont. These were caused by thawing action on several occasions during the winter season, followed by extremely cold periods. Downtown Montpelier was threatened by flooding from potential rains or thawing upstream. The Office of the Chief of Engineers authorized $130,000 for the New York District to remove the threat caused by the jams. Included in the $130,000 was $35,000 for construction of an ice boom in Montpelier to control the flow of ice and possibly eliminate jams. The river was opened under Corps' contracts which provided for mechanical removal and blasting of ice. Local authorities were unable to secure the proper easements required for the ice boom construction, therefore, this construction was cancelled.

Hardwick:

Under Section 205, a study was conducted in 1975 of alternative plans to prevent ice jam related flood damages along the Lamoille River at Hardwick. Alternatives considered include upstream ice retaining structures, levee and floodwall schemes, non-structural plans, channel modification plans and channel and dam alteration plans. The report indicated that ice jam flood protection is not economically justified. However, a number of measures that are implementable at the local level to minimize ice jam flood damage were recommended.

Richford:

Under Section 205, construction of a small local protection project on the Missisquoi River, consisting of over 4,000 feet of channel improvement in the village of Richford, was completed in 1963. The project is designed to prevent flood damages caused by ice jams in the vicinity of Big Island, at the sharp bend in the river immediately west of the center of Richford. Because of the formation of ice jams upstream of the existing Corps project at Richford, a study is presently being conducted to determine the feasibility of additional plans for protection at this site. The study is scheduled to be completed in 1981.

D. <u>Technical and Planning Assistance</u>

In addition to project planning and construction, the Corps of Engineers can also aid in the development of appropriate zoning regulations and offer technical assistance to states and local communities. For example, this report was prepared under the Flood Plain Management Services Program (Section 206 of the 1960 Flood Control Act). Within this program, the Corps provides technical and flood plain management planning assistance to State and local governments. Assistance activities include:

a. Evaluation of flood hazards

b. Assistance in the preparation of rules and regulations for flood proofing

c. Assistance in the preparation of flood emergency preparedness plans

d. Assistance in the preparation of regulations for flood hazard areas

Other help may be furnished by the Corps of Engineers' Cold Regions Research and Engineering Laboratory (CRREL) which has an Ice Engineering Branch, involved in the study of various ice problems. When a Division office of the Corps of Engineers investigates ice jam flooding in a specific community, CRREL provides input for that investigation. Additionally, they have completed a number of general studies concerning the ice jams. Many of these reports published by CRREL record data on recent ice jams in an effort to better predict areas of probable ice jams. These reports are helpful when seeking long term solutions to ice jams.

IX SUMMARY

Ice jam flooding is a frequent occurrence in the three northern New England states of Maine, New Hampshire and Vermont. Since 1970, 249 communities in these states have suffered from ice jam flooding. Of the 249 communities documented, 49 were identified as having frequent ice jam floods which caused substantial damage. Corps studies concerning ice jam flooding have recently been completed or are underway in Richford and Hardwick, Vermont, and in communities on the Aroostook River in Maine. An ice retention dam has been completed in Cherryfield, Maine, and an ice retention weir is under construction in Lancaster, New Hampshire. Each of the remaining 42 communities was visited in an effort to record past ice jam occurrences.

Flooding caused by ice jams can be more frequent and in some instances can exceed predicted flood elevations which assumed free flow conditions. Once a community recognizes the impacts of ice jam flooding, it has several options to consider. These include: flood plain management; development of emergency plans; ice retention structures;

channel improvements; floodwalls; dusting; and flood insurance. Most flood plain regulations are based on free flow conditions and do not consider ice jam floods which can occur more frequently and with greater impact. More stringent flood plain regulations, combined with a thorough emergency plan and the use of flood insurance should minimize future losses due to ice jam flooding in most communities. Communities that suffer heavy damages because of repeated ice jam flooding may decide to pursue more active solutions such as dusting, structural methods or channel improvements. Options presented in this report were described in general terms because it was not within the scope of this study to evaluate the alternatives of individual communities. Future studies under the Corps of Engineers' Section 206 program could address these issued more specifically.

In addition to the Section 206 program, the Corps has four continuing authorities which are applicable to the problem of ice jam flooding. Two of these authorities are implemented during emergency operations (PL 99 and Section 14). The other two authorities (Sections 205 and 208) consider long term solutions to the problem of ice jam flooding.

APPENDIX A

APPENDIX A
MAINE LOCAL INTERVIEWS

Androscoggin River
Bethel
Contact Norman Ness, Town Manager 16 June 1980

In seven of the past eleven years, ice jams, usually occurring in January have caused flooding on the Androscoggin River in Bethel. The usual source of ice is the upstream slow moving reaches of the river which have frozen into a solid ice cover. A mid-winter breakup of the upstream ice is caused by the combination of a slight thaw which weakens the ice and an increase in stream flow (due to rainfall) which has an uplifting force on the ice cover. The ice breaks into blocks of varying sizes, the average being 20′ x 20′ x 3′, and moves downstream until it hangs up at Hastings Island. The jam remains in place until it melts, or until pressure from upstream ice and water force the jam to break up Downstream of Hastings Island, the Androscoggin flows freely. Once the jam breaks, the ice moves downstream without further jamming.

The most destructive ice jam event in Bethel within the past 11 years occurred in January 1978. A 12 unit trailer park was flooded, approximately 5-10 residential structures had high water or damage, one house was lifted off its foundation and floated downstream, railroad bedding was destroyed, a lumber mill suffered heavy damage, several acres of farmland were inundated, Routes 2 and 26 were flooded and closed and 20 families were evacuated. Total damages were estimated to be between \$20,000 and \$30 000.

Because ice jam flooding in Bethel is a frequent occurrence residents and local officials have prepared a plan-of-action that is implemented to minimize the effects of flooding. The town stations one fire engine and police cruiser north of the flood limits on Route 26 so that isolated sections of the town may be serviced should an emergency arise. Businesses are alerted when an ice jam forms, thereby giving them some time to move merchandise and equipment to higher elevations. These preventative measures are often not completely effective because the sharp rise in water level leaves little time for action.

Bethel is in the emergency phase of the National Flood Insurance Program (NFIP). The town has adopted zoning regulations restricting development in flood hazard areas.

Androscoggin River
Canton
Contact Richard Maxwell, Canton CEP Director 16 June 1980

In three of the past eleven years, ice jams, usually occurring in January have caused flooding on the Androscoggin River in Canton and in the village of Gilbertville. The source of ice is the solid ice cover on the upstream reaches of the Androscoggin. The break up of the upstream ice is the combination of a slight thaw which weakens the ice and an increase in stream flow (due to rainfall) which has an uplifting force on the ice cover. The ice breaks into blocks of varying sizes, the average being 15′ x 15′ x 2′ and moves downstream until it jams at

Stevens Island and extends upstream for 2 miles. Several small "logging piers" that were once used to guide floating timber contribute to the slow-down and jamming of the ice floes. The ice blocks leave the river channel and are deposited on roadways and private property. The jam remains in place until it melts or until pressure from upstream ice and water force the jam to break up. Downstream of Stevens Island, the Androscoggin flows freely and once the jam breaks, it moves downstream without further jamming.

The January 1978 flood was the most severe ice jam flood experienced by Canton within the past ten years. Forty homes had 2-1/2 feet of water in their first floors, forcing their evacuation. One commercial building, several acres of farmland and Route 140 were inundated.

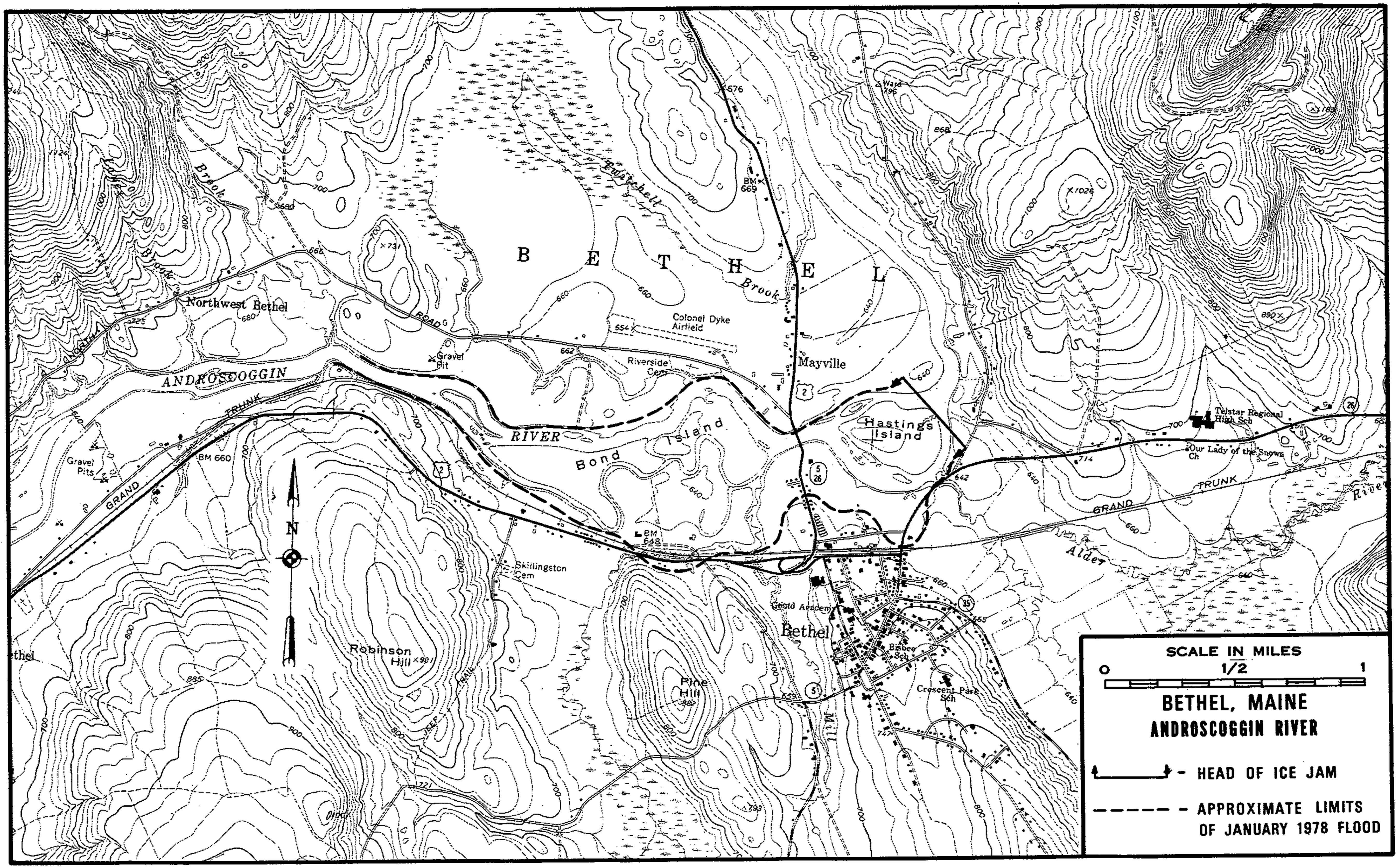
Residents and town officials have recognized ice jam flooding as a recurring problem and have formulated an emergency plan involving local officials and the State Bureau of Civil Emergency Preparedness (CEP). Emergency teams from the towns of Dixfield and Jay are notified of an impending crisis and are prepared to assist residents of Canton Point who are isolated on the northern bank of the Androscoggin.

Canton is in the emergency phase of NFIP and has adopted zoning regulations restricting development in flood hazard areas.

Kennebec River

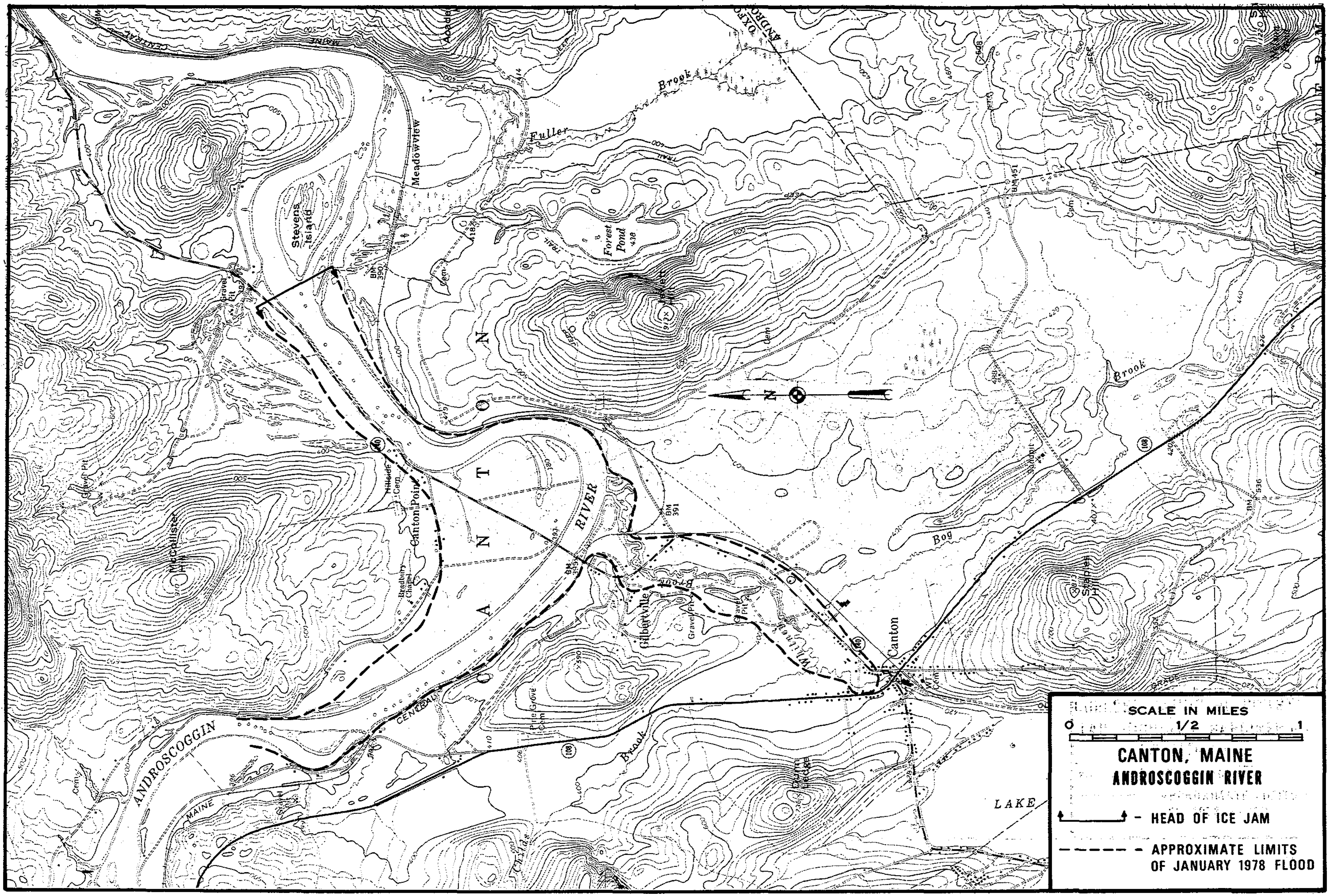
In each of the past 11 years, ice jams on the Kennebec River have caused flooding in Gardiner, Farmingdale, Hallowell and Augusta. The source of ice is the solid ice cover that forms on the slow moving upstream reaches of the Kennebec. The break up of the upstream ice is the combination of a March or January mid-winter thaw which weakens the ice, and an increase in stream flow (due to rainfall) which has an uplifting force on the ice cover. Once the ice breaks up, it moves downstream where it jams at Nehumkeag Island in South Gardiner. Ice also jams at sandbars 1,500 and 2,700 feet downstream of the former Route 226 bridge crossing, however these are infrequent occurrences while the jam at Nehumkeag Island is a constant problem. Coast Guard ice breakers are used to break up the jam with the exception of the February 1970 ice jam when 110 pounds of explosives cleared the jam and lowered the water level by 18 feet. Once the jam breaks up, it moves downstream to the Richmond-Dresden Bridge where another jam forms.

The piers of the bridge cause the ice to back up, creating a jam which extends upstream for approximately 2 miles. Coast Guard ice breakers also break up this jam, however, the ice only moves 1-1/2 miles downstream until it jams again at Little Swan Island. Downstream of Little Swan Island, the Kennebec flows freely into Merrymeeting Bay.



BETHEL
Northwest Bethel
Colonel Dyke Airfield
Riverside Cem
Mayville
ANDROSCOGGIN
RIVER
Bond Island
Hastings Island
Telstar Regional High Sch
Our Lady of the Snows Ch
GRAND TRUNK
Gravel Pit
Gravel Pits
Robinson Hill
Skillingston Cem
Pine Hill
Gould Academy
Bethel
Crescent Park Sch
Alder
N
SCALE IN MILES
0
1/2
1
BETHEL, MAINE
ANDROSCOGGIN RIVER
- HEAD OF ICE JAM
- APPROXIMATE LIMITS OF JANUARY 1978 FLOOD

PLATE 4


SCALE IN MILES
0
1/2
1
CANTON, MAINE
ANDROSCOGGIN RIVER
HEAD OF ICE JAM
APPROXIMATE LIMITS OF JANUARY 1978 FLOOD
ANDROSCOGGIN
RIVER
CANTON
Canton
Canton Point
Stevens Island
Meadowview
Fuller
Brook
Forest Pond
McCollister Hill
Gilbertville
Bog
Brook
LAKE

Augusta
Contact: Oliver Coulling City Engineer 19 June 1980

The December 1973 flood was the most serious ice jam event experienced by Augusta within the past 11 years Homes on Kennedy and Howard Streets were isolated and 53 businesses on Front and Water Streets were flooded. Flooded public property included the marina, post office, City Hall, library and public works storage area. Damage to private and public property was estimated at one quarter and one million dollars respectively.

In addition to the use of the ice breakers, the Augusta Public Works Department, and the State Civil Emergency Preparedness aid local merchants in their sandbagging efforts.

A Flood Insurance Study has been completed for the city of Augusta however, they have no flood plain zoning bylaws or regulations. They do enforce a shoreland zoning regulation which limits development near bodies of water.

Hallowell
Contact: Officer Elles, Hallowell Police Department 18 June 1980

The December 1973 ice jam flood was the most severe ice jam event in Hallowell within the past ten years. Approximately 80-100 businesses and residences located on Water, Front and Vaughn Streets suffered damage from the high water. Twenty to thirty people were evacuated from their homes, and Route 201, a major cross-town thoroughfare was closed to traffic.

Because of the frequency of ice jam flooding, local merchants are aware of the existing problem and take measures to protect their businesses. Emergency procedures such a traffic detouring, sandbagging, and evacuation are handled by the town. The police chief, who is the community civil defense director, controls the operations during emergencies. The town has communicated with the Maine Bureau of Civil Emergency Preparedness, but strictly on an advisory basis.

As a regular member of the National Flood Insurance Program, the town has adopted FEMA's minimum regulations restricting development in flood plain areas.

Farmingdale
Contact: Robert Nowell, Farmingdale Planning Board 18 June 1980

The December 1973, flood was the only ice jam event experienced by Farmingdale within the past 11 years that caused significant damage. During that event two structures were affected by high water. A commercial building, had its first floors flooded and one home was evacuated. U.S. Route 201, a major thoroughfare, was impassible causing a 2-1/2 mile detour for emergency vehicles. The Maine Central Railroad tracks that parallel the Kennebec River were flooded and closed.

Because of the infrequency of flooding in Farmingdale no specific detail emergency plans have been formulated. The town handles the evacuation of people and detour of traffic. The State Bureau of Civil Emergency Preparedness (CEP) has provided sandbags which were used to locally protect several residences, however, the high steep banks along the Kennebec protect the town against most high water events.

A Flood Insurance Study has been completed for Farmingdale and the town has adopted a minimum shoreland zoning ordinance which regulates new development in flood plain areas. Also, subdivision regulations pertinent to flood hazard areas have been adopted.

Gardiner
Contact: Kenneth Kokernak, City Manager 18 June 1980

The February 1970 ice jam flood was the worst ice jam event experienced by Gardiner in the past 11 years. Ice jams on the Kennebec caused Cobboseecontee Stream, which flows through the commercial district, to overflow its banks and inundate the surrounding area. The resultant floodwaters from the Kennebec and Cobboseecontee damaged approximately sixty (60) structures; hardest hit were those on Water and Kingsbury Streets. Thirty (30) businesses on the right bank of the Cobboseeconte had six feet of water in their basements. Ten (10) businesses along Water Street south of Route 226 had one to four feet of water, and a shopping plaza and parking lot were inundated with over one foot of water. Several city streets were flooded and closed, but no major traffic detours resulted. In addition, an empty 800,000 gallon gasoline storage tank was lifted from its moorings and floated down the Kennebec River, endangering downstream structures. According to State Representative Norman P. Whitzell, the three floods in 1970, 1971, and 1973 caused a total of one million dollars damage to private property.

Blasting was used to relieve the February 1970 ice jam at South Gardiner. One hundred ten (110) pounds of dynamite cleared a channel and broke up the head of the jam. The water level dropped from 18 to 10 feet subsequent to the blasting. Icebreakers have been used to keep the 16-foot shipping channel clear for year-round use. However, when the ice gets too thick, or when the temperature is consistently below freezing, ice breakers have been ineffective.

Because of the frequency of flooding in the city of Gardiner, local officials and residents are prepared for emergency action. Volunteers assist downtown merchants in moving merchandise to higher elevations. The town fire and police departments, in cooperation with the State Civil Emergency Preparedness provide sandbags and assist residents in evacuation.

Gardiner is a regular member of the National Flood Insurance Program, and has adopted FEMA's regulations regarding development and structural improvements in the flood plain.

Richmond
Contact: Stanley Griffin, Bridge-tender, Richmond/Dresden Bridge — 18 June 1980

The January 1978 flood was the most severe ice jam flood experienced by Richmond within the past 11 years.

Traffic across the Richmond/Dresden bridge was halted for two days and Route 24, a major road between Richmond and Gardiner was closed to traffic. Additionally, the boiler and pumping rooms of a mill were damaged by flooding.

Although ice jamming on the Kennebec River, is a frequent occurrence, damages to the town are minimal because the flooding is restricted to areas upstream of the town's central residential and business districts. The local fire and police departments coordinate the detouring of traffic and monitoring of water levels. State and Federal agencies including the Maine Bureau of Civil Emergency Preparedness (CEP), the Maine Department of Transporation (MDOT), the U S. Army Corps of Engineers, and the U.S. Coast Guard, have assisted during past ice jam emergencies. Ice breakers have been used extensively as a temporary solution. The Kennebec River services Augusta, Gardiner, and Hallowell shipping interests. During the January 1978 flood, three Coast Guard icebreakers attempted to clear the jam, however operations were suspended due to ice thickness, low water level in river, and sub-freezing temperatures. The jam was not broken up until March 1978.

Richmond is in the emergency phase of the National Flood Insurance Program and has adopted zoning ordinances regulating development in the flood plain.

Dresden, Pittston, Randolph, Chelsea
Contacts: Stanley Griffin, Bridge-tender, Richmond/Dresden Bridge
Robert Nowell, Farmingdale, Planning Board
Kenneth Kokernak, Gardiner City Manager
Gretchen Sliva, Randolph Town Clerk

The towns of Dresden, Pittston, Randolph, and Chelsea all lie on the east bank of the Kennebec River and have been subjected to ice jam flooding every year since 1970. These towns are affected by the jams that form in Gardiner and Richmond.

Because of the sharp rise in the easterly riverbank, little or no damage occurs in the limited flood plain. In Dresden, one residence was flooded and evacuated during the January 1978 and December 1973 ice jam events. The Richmond/Dresden Bridge was closed to traffic as were several backroads in Dresden. In Pittston there was no damage except for minor backroad flooding and streambank erosion. In Randolph, two commercial structures on Route 27 experienced minor basement flooding and portions of Route 27 were flooded. In Chelsea, one structure was threatened and two backroads were flooded.

Because of the infrequency of ice jam emergency situations, these four communities have not needed a detailed emergency plan. Road closings and sandbagging are usually handled by the towns themselves. Only Dresden has required State assistance. Chelsea and Randolph are in the regular phase and Pittston is in the emergency phase of the National Flood Insurance Program. All three have adopted regulations restricting development in flood hazard areas. Dresden is in the emergency phase of the National Flood Insurance Program, and has no flood plain regulations.

Piscataquis River
Medford, Maxfield and Howland
Contacts: Willis Lancaster, Piscataquis County CEP Director
Glenna Armour, Town Clerk, Howland, ME 27 June 1980

Every year since 1970 ice jams, have caused flooding on the lower Piscataquis River. Howland is the hardest hit town. Four jams occur on the lower Piscataquis, one each Medford and Maxfield and two in Howland. The source of ice is the solid ice cover on the upstream reaches of the Piscataquis River. The break up of the upstream ice is the combination of a slight thaw which weakens the ice and an increase in streamflow (due to rainfall) which has an uplifting force on the ice cover. The ice breaks into blocks of varying sizes, the average being 20′x20′x3′. Additionally, ice jams on the Pleasant River in Milo may release, sending more ice to jam downstream at any one of the four locations.

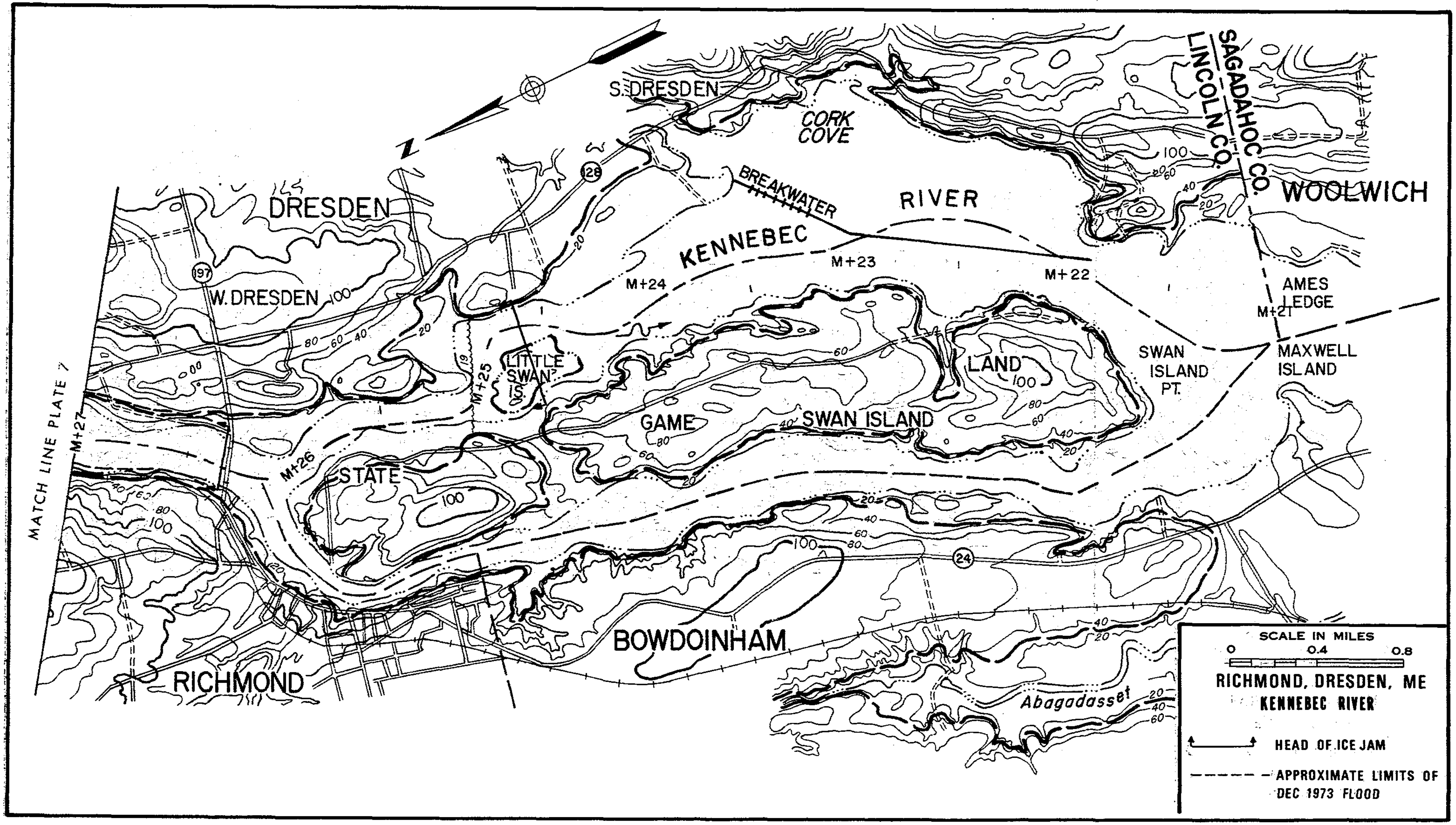
1. Ice jams at Schoodic Point in Medford cause only minor flooding, however, they do cause the closing of portions of Route 16, the major roadway for Milo, Medford, Maxfield and Howland and also result in streambank erosion.

2. Ice jams on a gravel bar at the Medford/Maxfield town line and extends upstream for approximately 1/2 mile. This jam causes portions of Route 16 to be closed, floods two homes and forces the evacuation of 2 families.

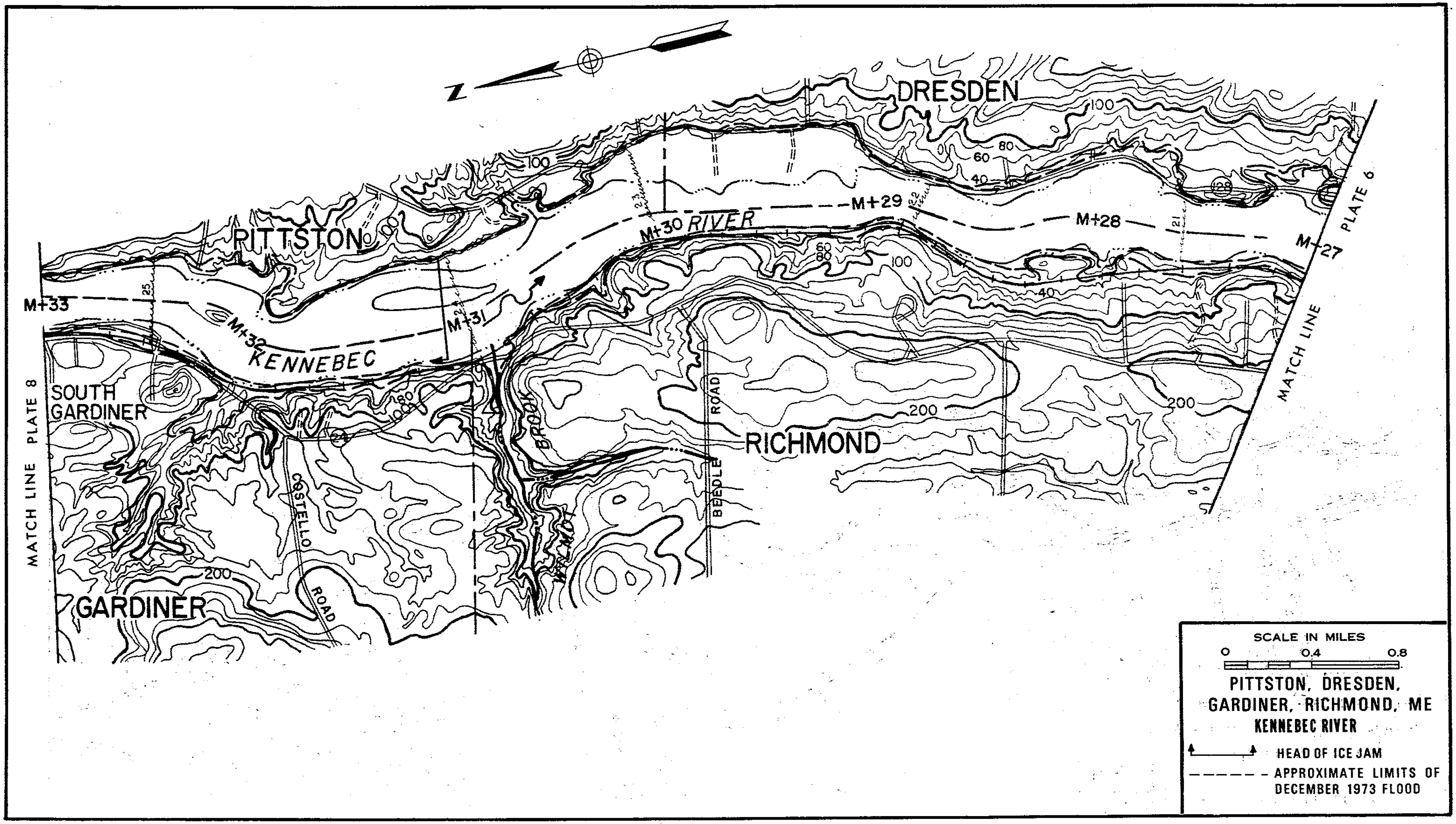
3. Ice jams at Lowell Island in Howland result in minor flooding and cause streambank erosion and the closing of portions of Route 16.

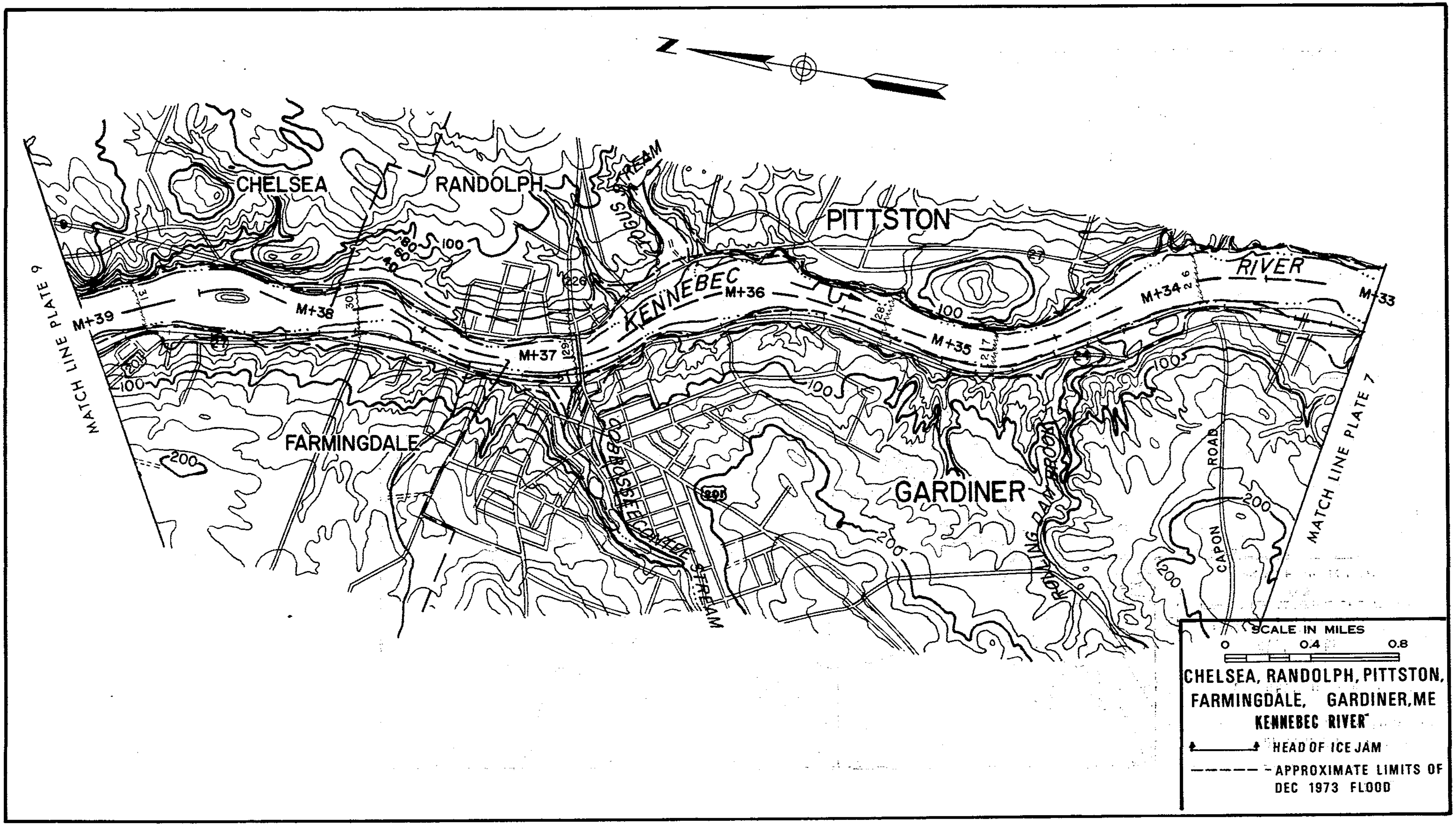
4. The most damaging ice jam on the Piscataquis River occurs at the dam in the center of Howland. The January 1978 flood was the most severe ice jam experienced by Howland within the past 11 years. Water Street and the Route 116 bridge were both impassable. A trailer park was flooded and 20 people were evacuated. Approximately 20 homes experienced basement flooding. The most critical problem, however, was that ice destroyed transmission lines, resulting in a loss of electrical power that left most homes without heat.

Because of annual problems of ice jam flooding in these communities, residents and local officals are prepared to take steps to minimize the damaging effects. The Army National Guard assists the town highway and fire departments in evacuating, sandbagging, and detouring efforts.



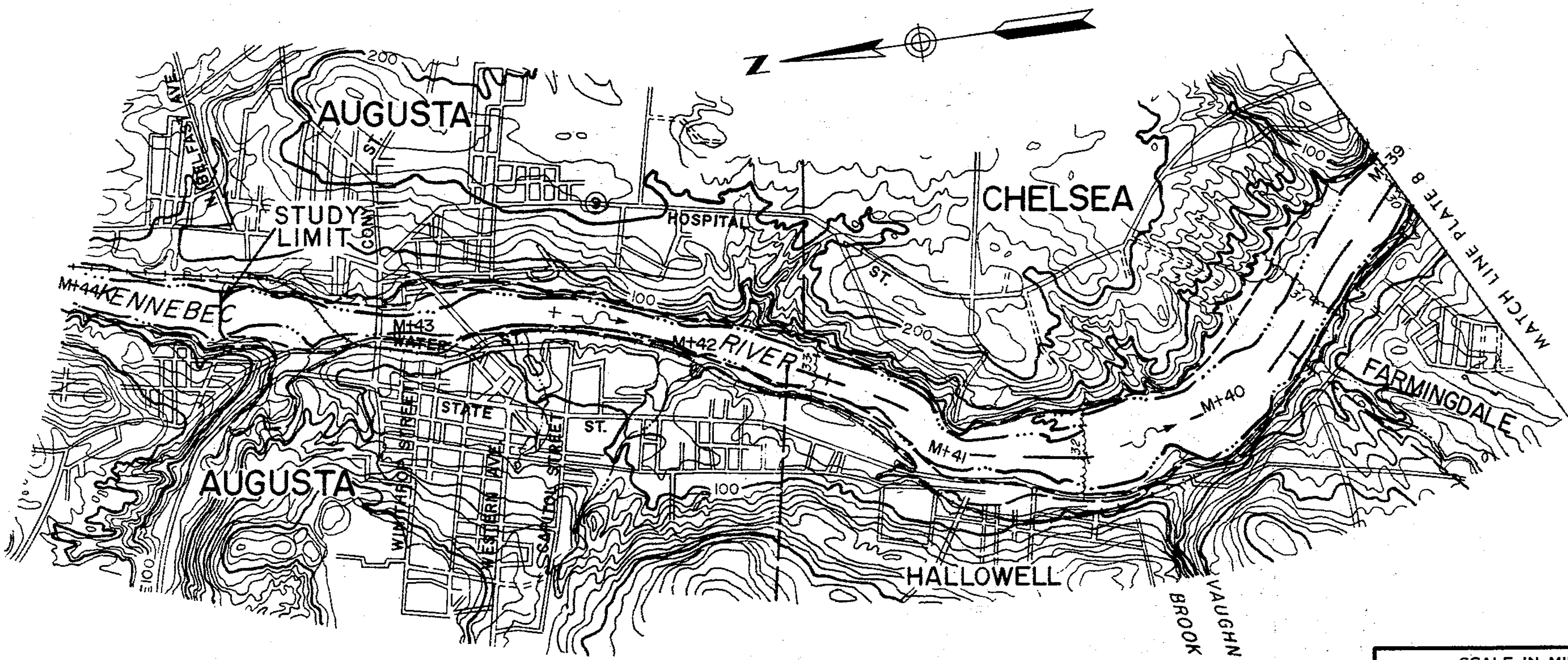
S. DRESDEN
CORK COVE
BREAKWATER
RIVER
KENNEBEC
DRESDEN
W. DRESDEN
WOOLWICH
LINCOLN CO.
SAGADAHOC CO.
AMES LEDGE
MAXWELL ISLAND
SWAN ISLAND PT.
LITTLE SWAN IS.
GAME
STATE
LAND
SWAN ISLAND
M+21
M+22
M+23
M+24
M+25
M+26
M+27
MATCH LINE PLATE 7
BOWDOINHAM
RICHMOND
Abagadasset
SCALE IN MILES
0 0.4 0.8
RICHMOND, DRESDEN, ME
KENNEBEC RIVER
HEAD OF ICE JAM
APPROXIMATE LIMITS OF DEC 1973 FLOOD


DRESDEN
PITTSTON
KENNEBEC
RIVER
M+33
M+32
M+31
M+30
M+29
M+28
M+27
SOUTH GARDINER
GARDINER
RICHMOND
COSTELLO ROAD
BEEDLE ROAD
BROOK
MATCH LINE PLATE 8
MATCH LINE PLATE 6
100
200
SCALE IN MILES
0 0.4 0.8
PITTSTON, DRESDEN, GARDINER, RICHMOND, ME
KENNEBEC RIVER
HEAD OF ICE JAM
APPROXIMATE LIMITS OF DECEMBER 1973 FLOOD



CHELSEA
RANDOLPH
PITTSTON
FARMINGDALE
GARDINER
KENNEBEC
RIVER
M+39
M+38
M+37
M+36
M+35
M+34
M+33
MATCH LINE PLATE 9
MATCH LINE PLATE 7
COBBOSSEECONTEE STREAM
ROLLING DAM BROOK
CAPON ROAD
SCALE IN MILES
0
0.4
0.8
CHELSEA, RANDOLPH, PITTSTON,
FARMINGDALE, GARDINER, ME
KENNEBEC RIVER
HEAD OF ICE JAM
APPROXIMATE LIMITS OF
DEC 1973 FLOOD

PLATE 8



SCALE IN MILES

0 0.4 0.8

CHELSEA, HALLOWELL, FARMINGDALE, ME
KENNEBEC RIVER

HEAD OF ICE JAM

APPROXIMATE LIMITS OF DEC 1973 FLOOD

Howland, Medford and Maxfield are in the emergency phase of the National Flood Insurance Program. Only Howland has adopted flood plain regulations.

Pleasant River
Milo
Contact: Willis Lancaster, Piscataquis County CEP Director 17 June 1980

In seven of the past eleven years, ice jams, usually occurring in January, have caused flooding on the Pleasant River in Milo. The source of ice is the solid cover on the upstream reaches of the Pleasant River. The break up of the upstream ice is the combination of a slight thaw which weakens the ice and an increase in streamflow (due to rainfall) which has an uplifting force on the ice cover. The ice breaks into blocks of varying sizes, the average being 15'x15'x3'. These block move downstream until they hang up at an oxbow 1/2-mile downstream of the Route 16 bridge. The jam extends upstream for approximately one mile and remains in place until it melts, or pressure from water and upstream ice forces the jam to break up. Downstream, the Pleasant River flows freely to its confluence with the Piscataquis River.

The January 1978 flood was the most severe ice jam flood experienced by Milo within the past ten years. Two homes were flooded and approximately 30 people were evacuated as a precautionary measure. Milo's major thoroughfare, Route 16, and several other roads were closed for several days.

Because ice jam flooding is a frequent occurrence, local officials are prepared to take steps to minimize the effects of flooding. Through the mutual efforts of the town's fire and police departments, emergency operations run smoothly. Emergency vehicles are positioned at key areas throughout the town so that they may service isolated sections of the community.

The town of Milo is in the regular phase of the National Flood Insurance Program and has adopted regulations restricting development in flood hazard areas.

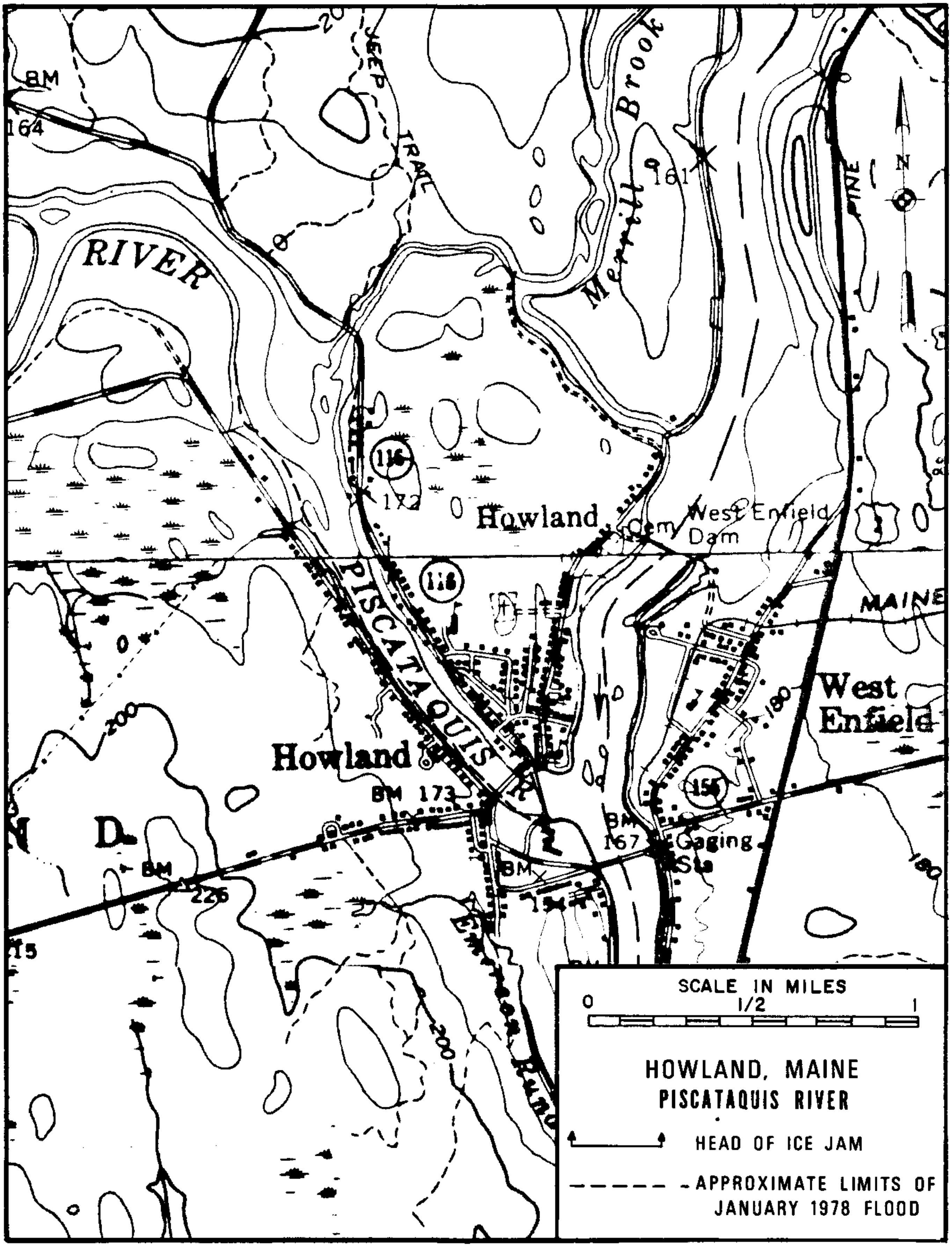
Sandy River
Farmington
Contact: Dan Chandler, Superintendent, 17 June 1980
Farmington Water Treatment Facility

Ice jams usually occurring in January have been responsible for flooding on the Sandy River in Farmington in each of the past 11 years. The source of ice is the solid ice cover on the upstream reaches of the Sandy River. The break up of the upstream ice is the combination of a slight thaw which weakens the ice and an increase in streamflow (due to rainfall) which has an uplifting force on the ice cover. The ice breaks into blocks of varying sizes, the average being 20'x20'x2'. Blasting of a small jam in the upstream town of Phillips has significantly increased the ice jam problems in Farmington. The broken and blasted ice moves downstream past the center of town until jamming at the oxbow near the town wastewater treatment facility. The ice jam extends upstream for nearly three miles. Both blasting of the ice jam and preventative dusting of the solid ice cover have been implemented successfully. Once broken up, the ice moves downstream without any further jamming.

The January 1978 flood was the most damaging ice jam flood experienced by Farmington in the past 11 years. During that flood approximately 10-15 homes and 10 commercial businesses were flooded and suffered heavy losses. The town recreation fields, comprised of several ballfields and tennis courts were inundated. Several people were rescued from atop their water-surrounded automobiles. The two major thoroughfares in town, Route 2 and Routes 4-27 were closed for several days as were various local roads that were accessible only by boat. Between 30 and 40 residents were evacuated and housed at the high school and University of Maine.

An emergency plan, coordinating the efforts of local officials and the State Bureau of Civil Emergency Preparedness (CEP), has been formulated to deal with this annual problem. Flood warnings advise retailers to move their merchandise and destructibles above previous high water marks.

Farmington is in the emergency phase of the National Flood Insurance Program and new construction in the town must have the lowest floor elevated one foot above the base flood elevation.



SCALE IN MILES
0
1/2
1
HOWLAND, MAINE
PISCATAQUIS RIVER
HEAD OF ICE JAM
APPROXIMATE LIMITS OF
JANUARY 1978 FLOOD
RIVER
PISCATAQUIS
Howland
West Enfield
West Enfield Dam
Merrill Brook
JEEP TRAIL
Gaging Sta
MAINE
BM 173
BM 226
BM 167
164
161
172
116
155
200
180
N

PLATE 10

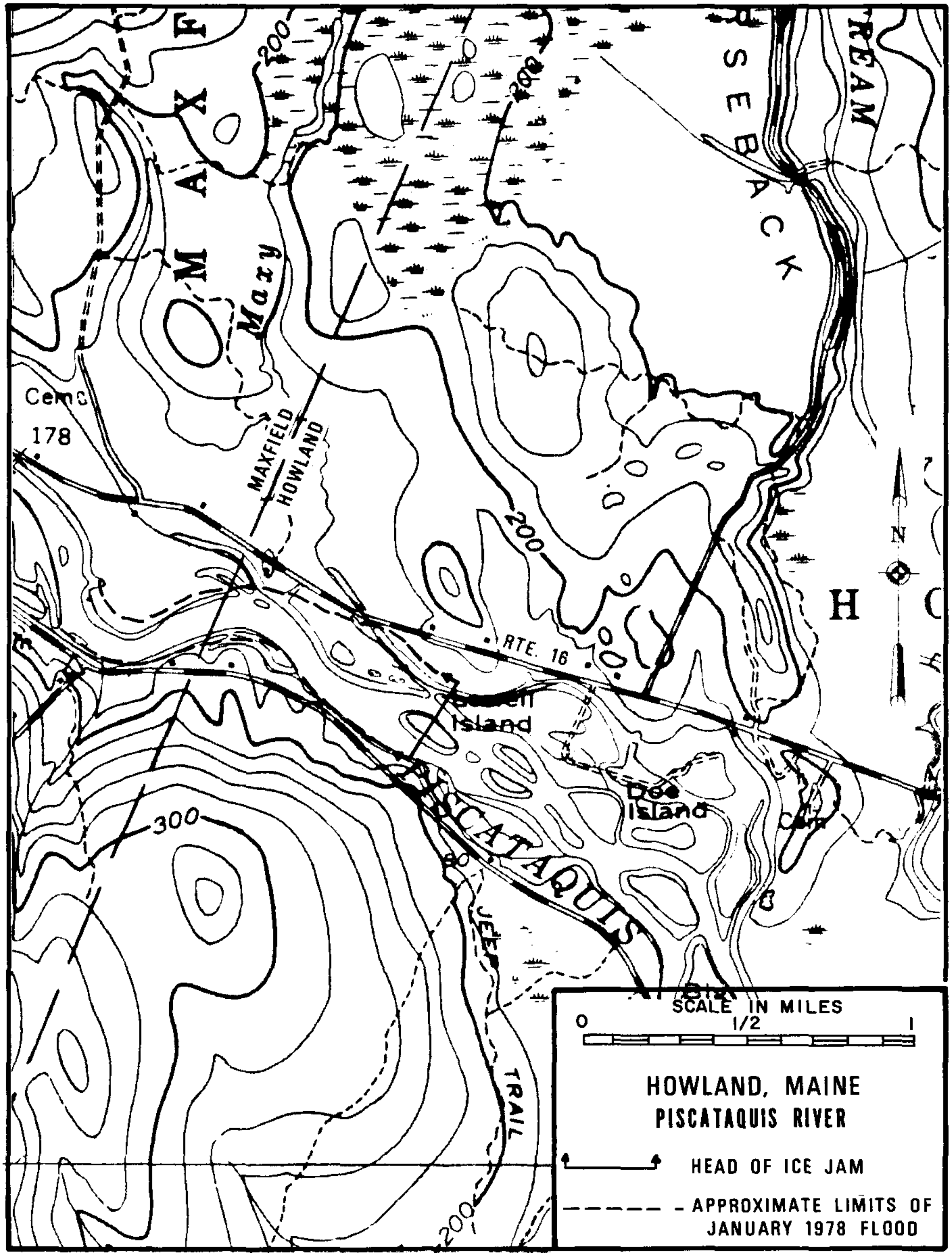
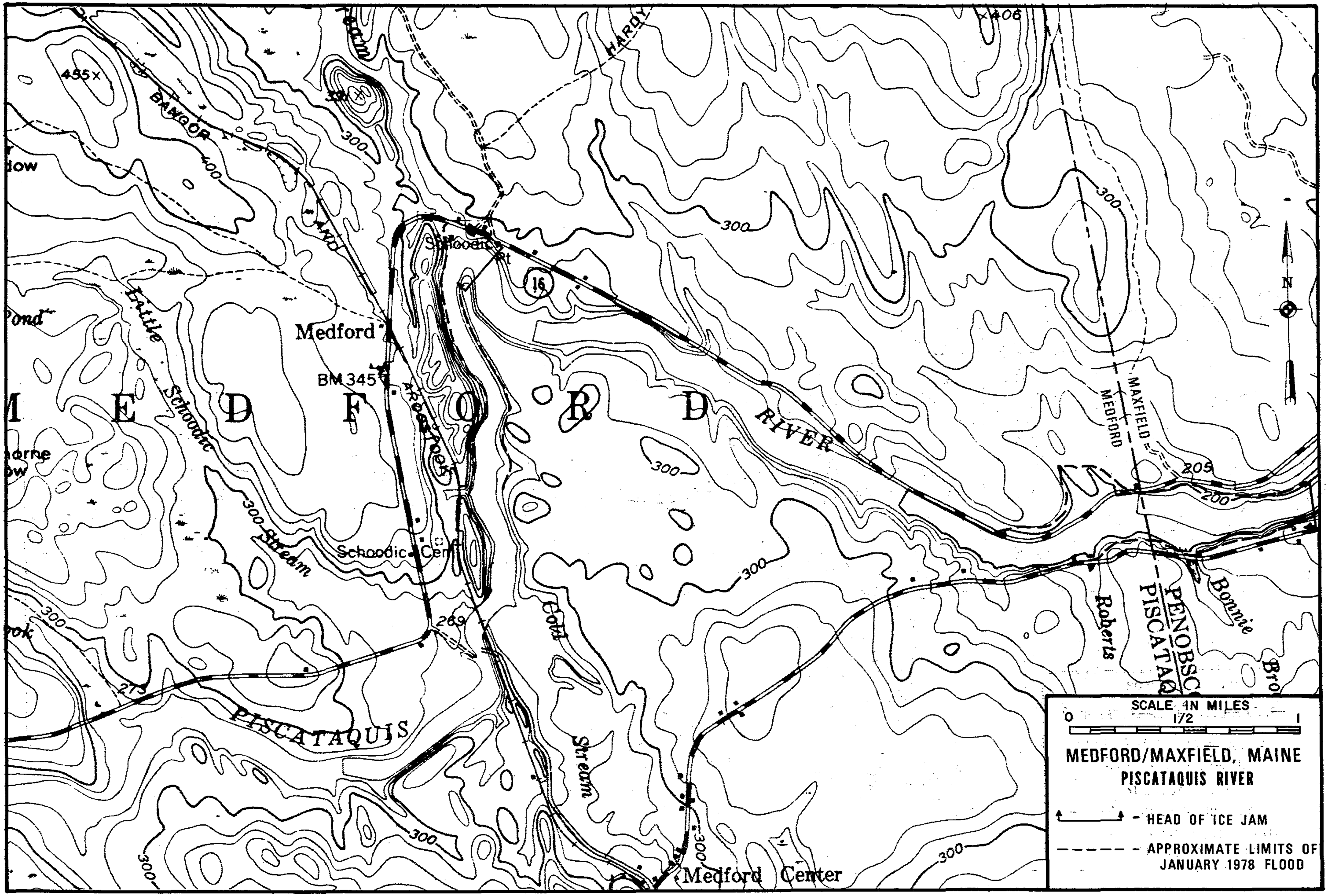

Maxy
Cem
178
MAXFIELD
HOWLAND
200
RTE. 16
Island
Doe
Island
300
TRAIL
SCALE IN MILES
0
1/2
1
HOWLAND, MAINE
PISCATAQUIS RIVER
HEAD OF ICE JAM
APPROXIMATE LIMITS OF
JANUARY 1978 FLOOD

PLATE 11


SCALE IN MILES
0
1/2
1
MEDFORD/MAXFIELD, MAINE
PISCATAQUIS RIVER
HEAD OF ICE JAM
APPROXIMATE LIMITS OF JANUARY 1978 FLOOD
MEDFORD
Medford
BM 345
Schoodic
Schoodic Cen
Medford Center
PISCATAQUIS
RIVER
Little Schoodic Stream
Cold Stream
BANGOR AND AROOSTOOK
HARDY
MAXFIELD
MEDFORD
PENOBSC
PISCATAQ
Roberts
Bonnie
N
455
406
269
273
205
200
300
400

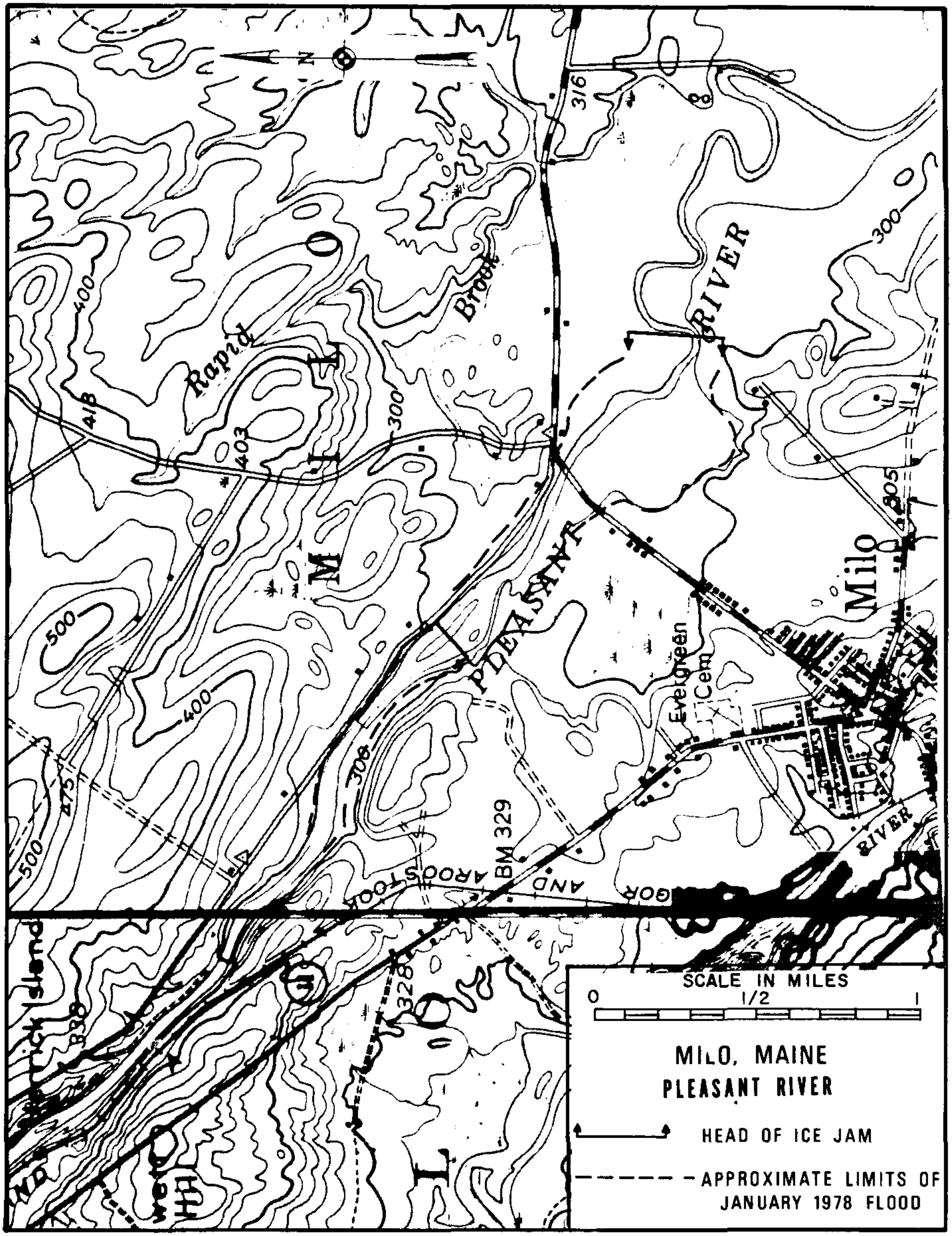

SCALE IN MILES
0
1/2
1
MILO, MAINE
PLEASANT RIVER
HEAD OF ICE JAM
APPROXIMATE LIMITS OF JANUARY 1978 FLOOD
Rapid
Brook
RIVER
PLEASANT
Milo
Evergreen Cem
BM 329
300
400
500
316
418
403
305
308
475
328
338

PLATE 13

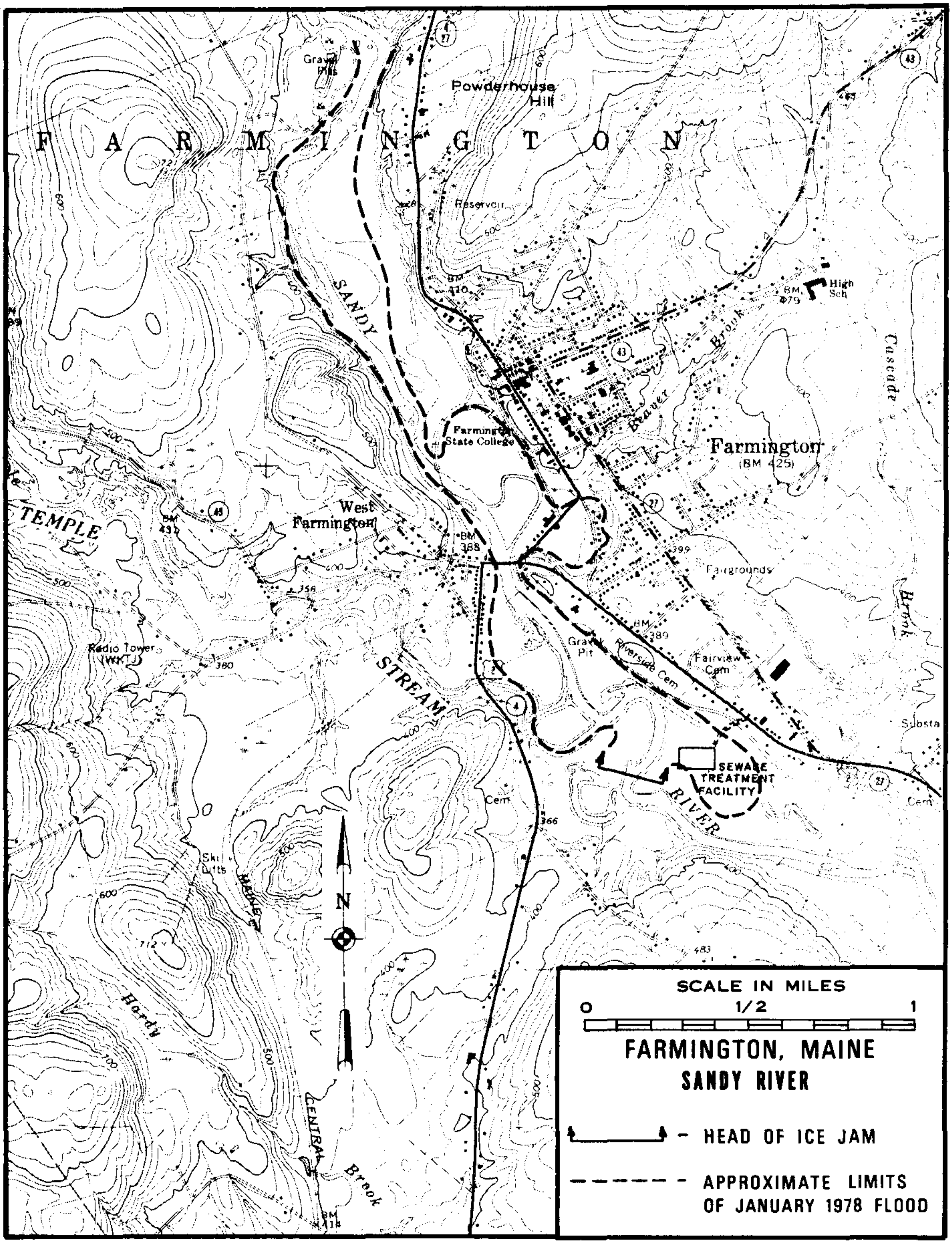

F A R M I N G T O N
Powderhouse Hill
Reservoir
SANDY
Farmington State College
Farmington
(BM 425)
High Sch
Beaver Brook
Cascade Brook
West Farmington
TEMPLE
Fairgrounds
Radio Tower (WKTJ)
Gravel Pit
Riverside Cem
Fairview Cem
STREAM
SEWAGE TREATMENT FACILITY
RIVER
Cem
Ski Lifts
Hardy
CENTRAL MAINE
Brook
N
SCALE IN MILES
0
1/2
1
FARMINGTON, MAINE
SANDY RIVER
- HEAD OF ICE JAM
- APPROXIMATE LIMITS OF JANUARY 1978 FLOOD

PLATE 14

APPENDIX B

APPENDIX B

NEW HAMPSHIRE LOCAL INTERVIEWS

Ammonoosuc River
Lisbon
Contact Richard Grayson, Libson Chief of Police 5 June 1980

In nine of the past eleven years, ice jams, usually occurring in January or March have caused flooding on the Ammonoosuc River in Lisbon. The source of ice is the solid ice cover on Salmon Hole Brook, Gale River and the upstream reach of the Ammonoosuc River. In once instance, the blasting of a jam on the Gale River in Sugar Hill significantly increased the ice jam problems in Lisbon. The break up of the upstream ice is the combination of a slight thaw which weakens the ice and an increase in streamflow (due to rainfall) which has an uplifting force on the ice cover. The ice breaks into blocks of varying sizes, the average being 6´x6´x2´, and moves downstream until it hangs up at the dam at School Street. The jam extends from the dam upstream for approximately 2 miles, most of the ice is deposited in a golf course and open fields. The jam remains in place until it melts, or until pressure from water and upstream ice force the jam to break up. Downstream of the dam, the Ammonoosuc flows freely and once the jam breaks up, it moves downstream without further jamming.

The March 1978 flood was the most severe ice jam flood experienced by Lisbon within the past eleven years. During that ice jam event, 3-4 homes were evacuated, 5 commercial buildings were flooded, new cars in a sales lot were damaged by floating ice, approximately 600 feet of railway was washed out, a historic schoolhouse was moved from its foundation and many parts of Route 302, the town´s main thoroughfare were inudnated, closing the road for 2 days. When the jam finally broke up the force of the moving ice noticeably shook the School Street Bridge and tremors were felt in nearby buildings.

Because ice jam flooding is an almost annual occurrence, residents and local officals are prepared to take steps to minmize the effects of flooding. Fire and police vehicles are stationed in key areas throughout the town and are able to service most of the community when Route 302 is impassable. Owners of commercial buildings move equipment and merchandise above previous high water marks. However, preventive measures are often too little and too late, because of the difficulty in predicting when flooding will occur. Often minor upstream jams will break up and cause a sudden release of water. This sudden release of water has caused flood heights to increase more than 2 feet within 1/2 hour.

Lisbon is in the emergency phase of the National Flood Insurance Program and has no regulations restricting flood plain development.

Connecticut River
Lebanon
Contact: Robert Pantel, Lebanon City Engineer 23 July 1980

During the past eleven years, the city of Lebanon has been affected by ice jam flooding on the Connecticut River only twice. Within the past eleven years ice jams have not caused flooding on the Mascoma River which has been free of jams since the removal of the Hanover Street bridge. The two ice jams on the Connecticut River also caused flooding in Hartford, Vermont, and they are discusssed in the Hartford report.

The city has been threatened by high water from ice jams and although no structures have been damaged, the water has come close to flooding the two shopping plazas in West Lebanon. The only damage suffered by Lebanon as a result of ice jam flooding within the past ten years was in February 1976. During that ice jam event, a 60-foot section of sewer interceptor pipeline was severely damaged, causing raw sewage to be discharged into the Connecticut River.

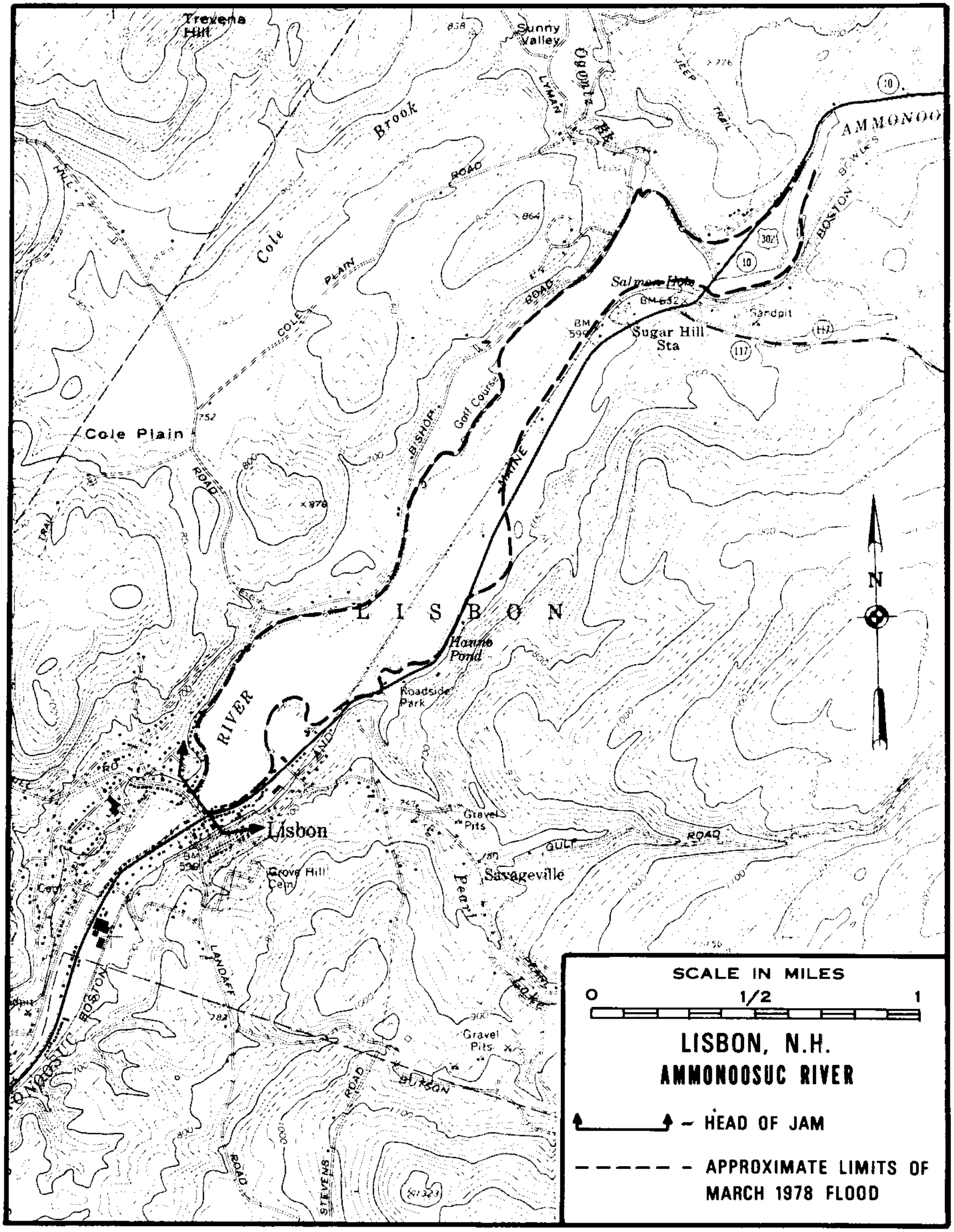
The city of Lebanon is in the regular phase of the National Flood Insurance Program and has adopted FEMA's minimum regulations restricting development in the flood plain.

Connecticut River
Stratford
Contact: James Chappel, Stratford Fire Department 10 June 1980

In four of the past eleven years, ice jams, usually occurring in February or March have caused flooding on the Connecticut River in North Stratford. The source of ice is the solid cover on the upstream reaches of the Connecticut River and its tributaries. The break up of the upstream ice is the combination of a slight thaw which weakens the ice and an increase in streamflow (due to rainfall) which has an uplifting force on the ice cover. The ice breaks into blocks of varying sizes, the average being 25'x25'x1-1/2', and moves downstream until it jams at a bend in the river 3,000 feet downstream of the Bloomfield, Vermont - North Stratford bridge over the Connecticut River. A sandbar and boulders in the river at the bend contribute to the problem at this site. The jam extends upstream for approximately 1/2 mile.

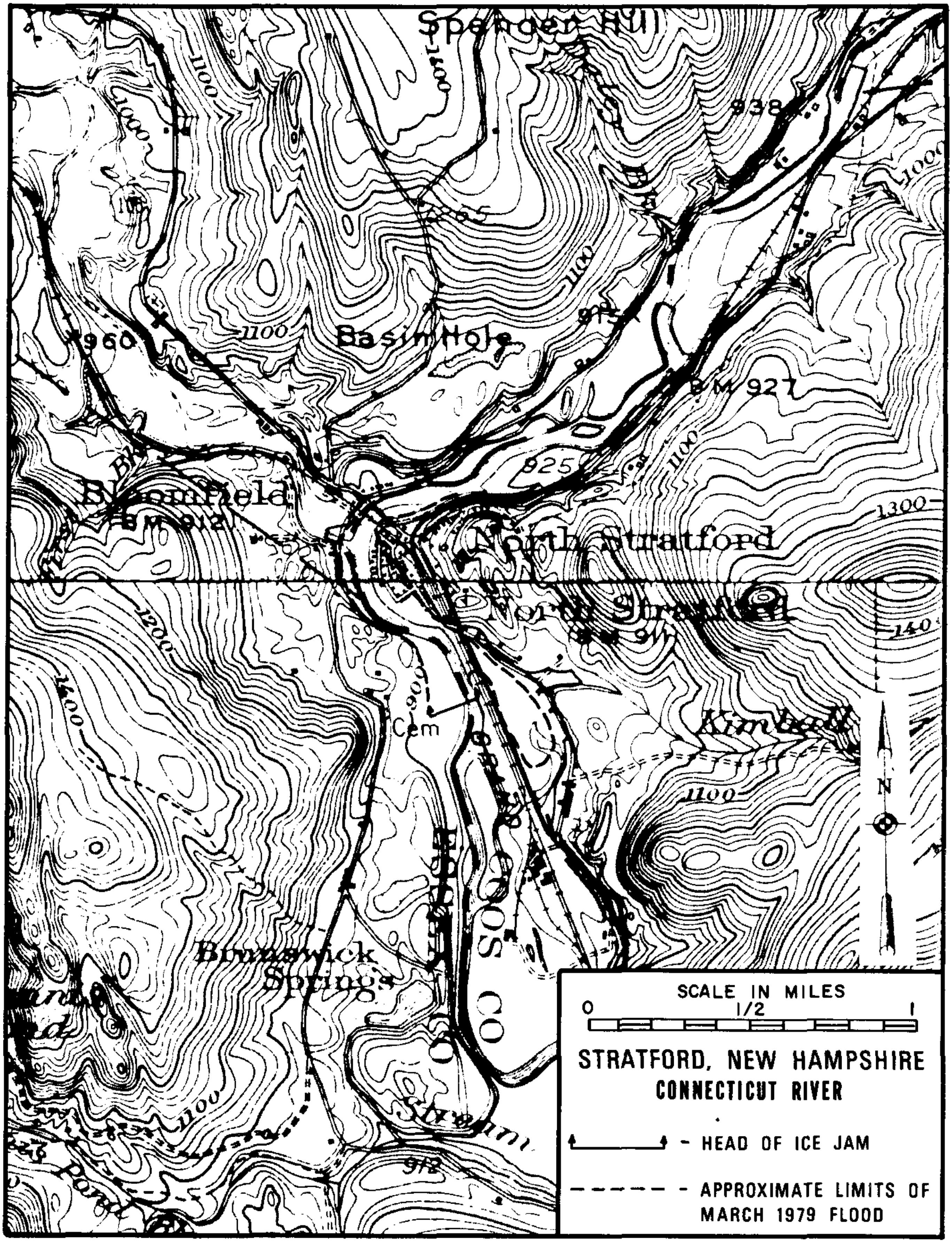
The March 1979 ice jam flood was the worst experienced by the town of Stratford. During that ice jam event, 120 homes, a paper mill and Route 3 were flooded and tracks belonging to Grand Trunk Railroad were washed away. Damage was estimated to be between 3 and 4 million dollars.

The town is in the emergency phase of the Flood Insurance Program and has no flood plain zoning regulations. However, since of the March 1979 flood, the town has recognized the need for flood plain management and working with FEMA, they are in the process of relocating 29 homes in the flood plain. The town expects to continue a strong flood plain management program, stressing flood insurance and flood proofing.



Trevena Hill
Sunny Valley
Ogontz Bk
Cole Brook
Cole Plain
ROAD
Salmon Hole
Sugar Hill Sta
Sandpit
Golf Course
BISHOP
L I S B O N
Hanno Pond
Roadside Park
RIVER
Lisbon
Grove Hill Cem
Gravel Pits
Savageville
GULF ROAD
AMMONOOSUC
BOSTON
LANDAFF
STEVENS
DUTSON
N
SCALE IN MILES
0
1/2
1
LISBON, N.H.
AMMONOOSUC RIVER
– HEAD OF JAM
– APPROXIMATE LIMITS OF MARCH 1978 FLOOD

PLATE 15


Spencer Hill
Basin Hole
Bloomfield
North Stratford
Cem
Brunswick Springs
Kimball
COOS CO
ESSEX CO
BM 927
SCALE IN MILES
0
1/2
1
STRATFORD, NEW HAMPSHIRE
CONNECTICUT RIVER
- HEAD OF ICE JAM
- APPROXIMATE LIMITS OF MARCH 1979 FLOOD

Contoocook River
Henniker
Contact: Ken Ward, Henniker Civil Defense Director 4 June 1980

In nine of the past eleven years, ice jams, usually occurring in the spring have caused flooding on the Contoocook River in Henniker. The source of ice is the solid ice cover on the upstream reach of the Contoocook. The breakup of the upstream ice is the combination of a slight thaw which weakens the ice and an increase in streamflow (due to rainfall) which has an uplifting in force on the ice cover. The ice breaks into blocks of various sizes, the average being 10'x10'x1-1/2' and moves downstream until jamming at the abutments of the abandoned railroad bridge, approximately 1 mile upstream of the center of town. The jam extends upstream for 1 mile to the Route 202 bridge over the Contoocook.

It remains in place until it melts, or until pressure from water and upstream ice force the jam to break up. The results of the jam are that the Route 202 bridge is closed and the Contoocook Valley Paper Mill suffers extensive damage.

A second ice jam occurs downstream, in the center of town at the bridge over the Contoocook River. This jam is not as frequent as the first but has occurred 3 times in the past ten years. It causes flooding to a paint factory and 2 houses. Additionally, residents fear that the ice may damage or even destroy the bridge isolating half of the town.

The Corps of Engineers' Hopkinton-Everett Lakes flood control dams downstream have caused the relocation of many structures which were located in the flood plain. The town is in the regular phase of the Flood Insurance Program but has no zoning regulations restricting flood plain development.

Contoocook River and Nubanusit Brook
Peterborough 9 June 1980
Contact: Carl Wood, Hillsborough County Civil Defense Director

In each year since 1970, ice jams on the Contoocook River and Nubanusit Brook have caused flooding in Peterborough. Most severly affected are the businesses in the center of town adjacent to the confluence of Nubanusit Brook with the Contoocook River. On both streams, the source of ice is the solid ice cover on the upstream reaches. The break up of the upstream ice is the combination of a slight thaw which weakens the ice and an increase in streamflow (due to rainfall) which has an uplifting force on the ice cover. The ice breaks into blocks of varying sizes, the average being 5'x5'x2' and moves downstream until jamming at several locations.

Ice has jammed at many of the small dams on Nubanusit Brook, but the major jam is caused by the abutments of an old railraod bridge and a jam on the Contoocook River. The jam extends upstream approximately 600 feet and remains in place until it melts, or pressure from water and upstream ice force the jam to break up Regulation of the Corps of Engineers' Edward McDowell Dam, upstream on Nubanusit Broock reduces the effects of this ice jam

On the Contoocook River, ice jams at three locations:

1. Ice jams at the narrow bridge at Sharon Road near the Harris Sand Mill, causing flooding to the Harris Sand Mill and 2 homes. Ths jam is not considered serious and remains in place until it melts, or pressure from water and upstream ice force the jam to break up. Downstream, there is a jam in the center of town.

2. Ice jams at the dam 150 feet upstream of the Main Street bridge in the center of town. This jam, combined with the jam on Nubanusit Brook cause most of the problems in Peterborough between 10 and 15 businesses are flooded with 1 to 3 feet of water in their first floors Downstream, there is an ice jam at old North Dam.

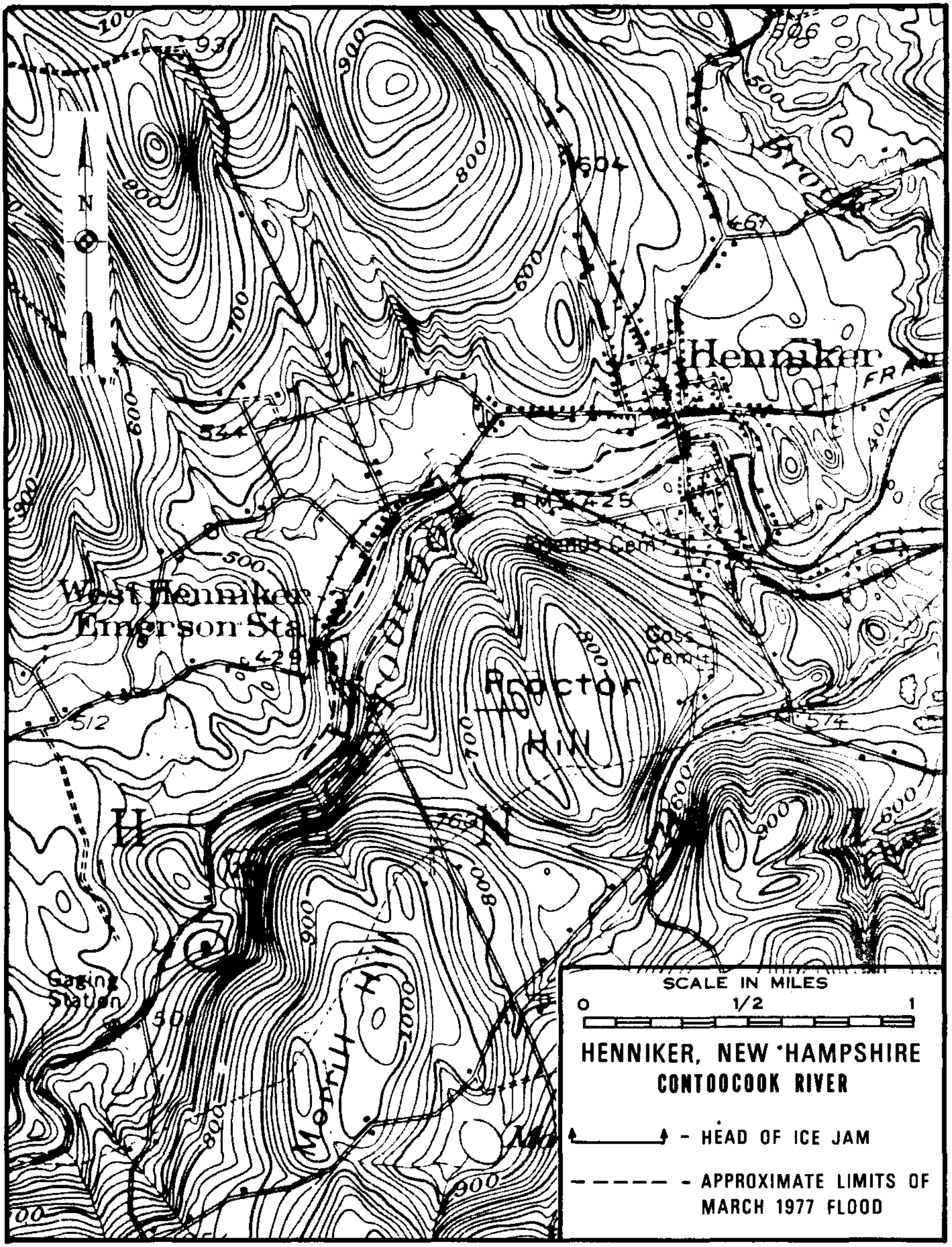
3. Ice jams at the old North Dam, flooding a motel. The town has attempted to remove this jam by blasting, but has not been successful in relieving the flooding. Downstream, ice jams occur in the town of Henniker.

The town of Peterborough is in the regular phase of the National Flood Insurance Program and has adopted FEMA's minimum regulations restricting development in the 100-year flood plain.

Gale River
Franconia and Sugar Hill
Contact: Robert Gilbert, Franconia Police Department
Gary Young Sugar Hill, Chief of Police
Luke Hannah, Sugar Hill resident   30 May 1980

In nine of the past eleven years, ice jams usually occurring between January and April, have caused flooding on the Gale River in the towns of Franconia and Sugar Hill. The source of ice is the solid ice cover on the upstream reach of the Gale River and the many small tributaries of the Gale. The break up of the upstream ice is the combination of a slight thaw which weakens the ice and an increase in streamflow (due to rainfall) which has an uplifting force on the ice cover. The ice breaks into blocks of varying sizes, the average being approximately 10' x 10' x 2' and moves downstream. The ice jams at three specific areas on the Gale, one in Franconia, one in Sugar Hill and one at the Franconia-Sugar Hill line.

1. Ice jams at a sharp bend approximately 500 feet downstream of the Route 18 bridge over the Gale River. Sand and gravel deposits contribute to the problem. The ice jam is approximately 250 feet long and causes a small brook to back up through a culvert under Route 18. The flooding on this brook does not affect any structures, but it does inundate a roadway which is the only access to a 6 home housing development. This



N
Henniker
West Henniker
Emerson Sta
Proctor Hill
Gaging Station
Morrill Hill
SCALE IN MILES
0
1/2
1
HENNIKER, NEW HAMPSHIRE
CONTOOCOOK RIVER
- HEAD OF ICE JAM
- APPROXIMATE LIMITS OF MARCH 1977 FLOOD

PLATE 17

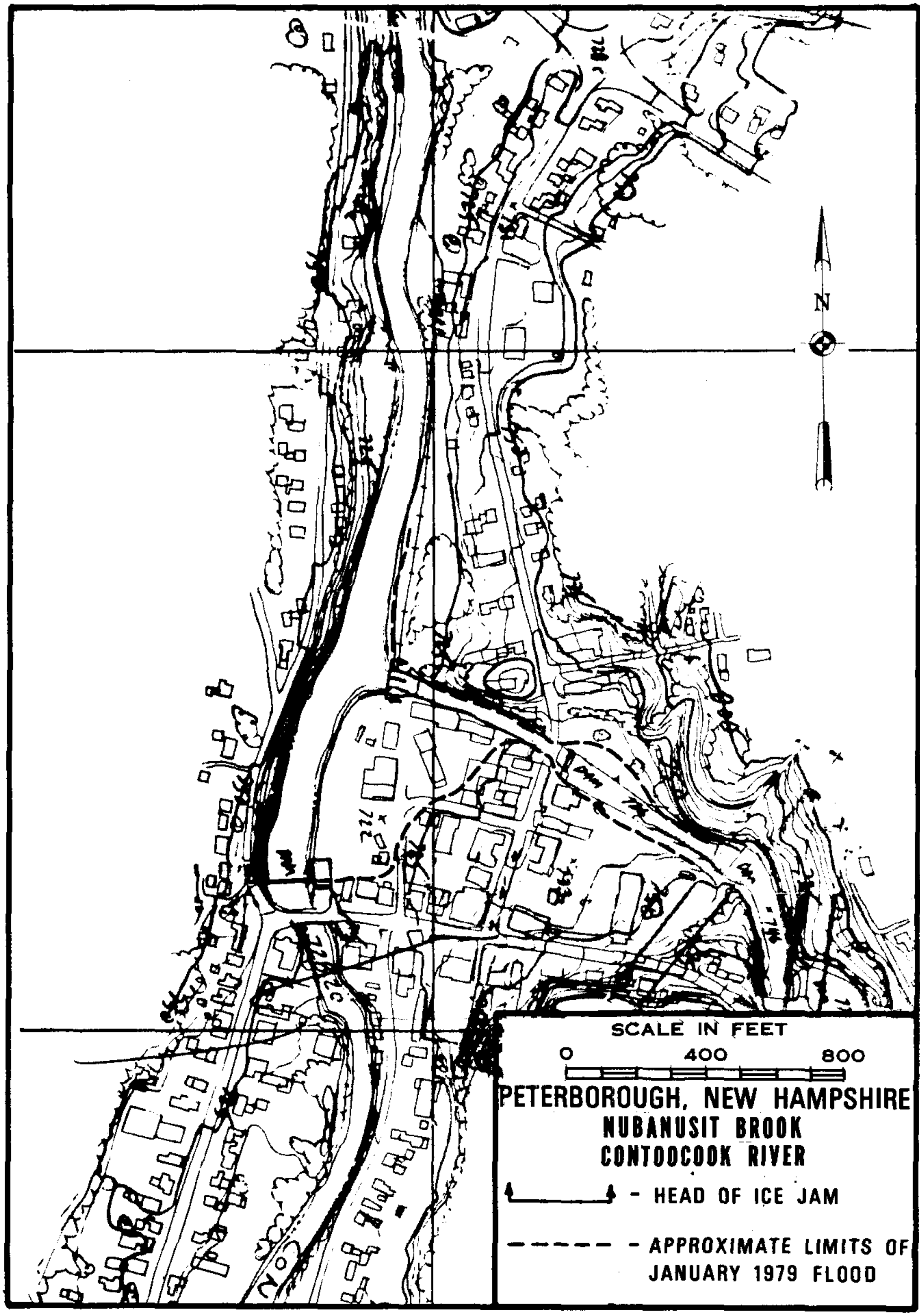

N
SCALE IN FEET
0
400
800
PETERBOROUGH, NEW HAMPSHIRE
NUBANUSIT BROOK
CONTOOCOOK RIVER
- HEAD OF ICE JAM
- APPROXIMATE LIMITS OF JANUARY 1979 FLOOD

PLATE 18

jam also has caused the Gale to reach a stage which is within 1-foot of flooding the fire and police station as well as Route 18, is the roadway directly connecting the town to the fire and police station. Downstream there are several jams on the Gale River.

2. Ice jams at a bend in the Gale River just downstream of the branch office of Littleton National Bank Gravel and sand deposits contribute to the problem at this site. There are no other obstructions or constrictions in this reach of the Gale. The March 1972 event was the worst ice jam flood at this site within the past eleven years. The jam caused flooding to 5 homes, 1 motel, a bank, and portions of Route 18, the village's main throughfare.

Ice jams also occur at various sites on the Gale River as it runs along the village of Franconia. The cause of these jams are the gravel and sand bars in this reach of the Gale. These jams cause flooding to many structures located along the river. The affected structures include 2 homes, 1 motel, 1 restaurant and a service station.

3. An ice jam occurs at a sharp bend in the river 500 feet downstream of a small private bridge in Sugar Hill. Again sand and gravel deposits contribute to this problem. The ice backs up for 1/4 mile and causes flooding to 2 homes, farmland and roadways. Blasting has been successfully attempted at this site, but the release of the jam caused further problems downstream on the Ammonoosuc River in Lisbon.

Both Sugar Hill and Franconia are in the emergency phase of the National Flood Insurance Program, but niether have any zoning restricting development in the flood plain.

Baker and Pemigewasset Rivers
Plymouth and Holderness
Contact: Barry Wescott, Plymouth Civil Defense Director 29 May 1980

In each of the past eleven years, ice jams, usually occurring in January or March have caused flooding on the Baker River in Plymouth and on the Pemigewasset River in Plymouth and Holderness.

On the Barker River, the source of ice is the solid ice cover on the upstream reach of the Baker. The breakup of the ice is the combination of a slight thaw which weakens the ice and an increase in streamflow (due to rainfall) which has an uplifting force on the ice cover. The ice breaks into blocks of varying sizes, the average being 15'x15'x2' and moves down stream where it jams on a sand bar approximately 3 miles upstream of the confluence of the Baker with the Pemigewasset River. There are many sand bars in this area and it is unknown if the jam occurs at the same site each year. The ice jam is approximately 1 mile long and extends upstream past the Smith Road covered bridge. The jammed ice comes within 3 feet of the covered bridge, threatening to cause serious damage to the bridge. The jam results in flooding to 2 homes, and a trailer sales lot containing approximately 40 trailers. Portions of Loon Lake and Fairgrounds Road are also inundated, isolating 3 homes. The jam remains in place until it melts or until pressure from water and upstream ice force the jam to break up. Downstream of the jam, the Baker River is clear for approximately 2 miles where another ice jam forms.

A second ice jam occurs at the confluence of the Baker with the Pemigewasset River. The cause of this jam is also a sand bar, but ice on the Pemigewasset can also cause an ice jam at this site. The jam extends upstream for approximately 1 mile and causes flooding to 2 commercial buildings, the fairgrounds, 1 house and portions of Fairground Road. The town well fields are inundated and damage to the pumping station threatens the town water supply.

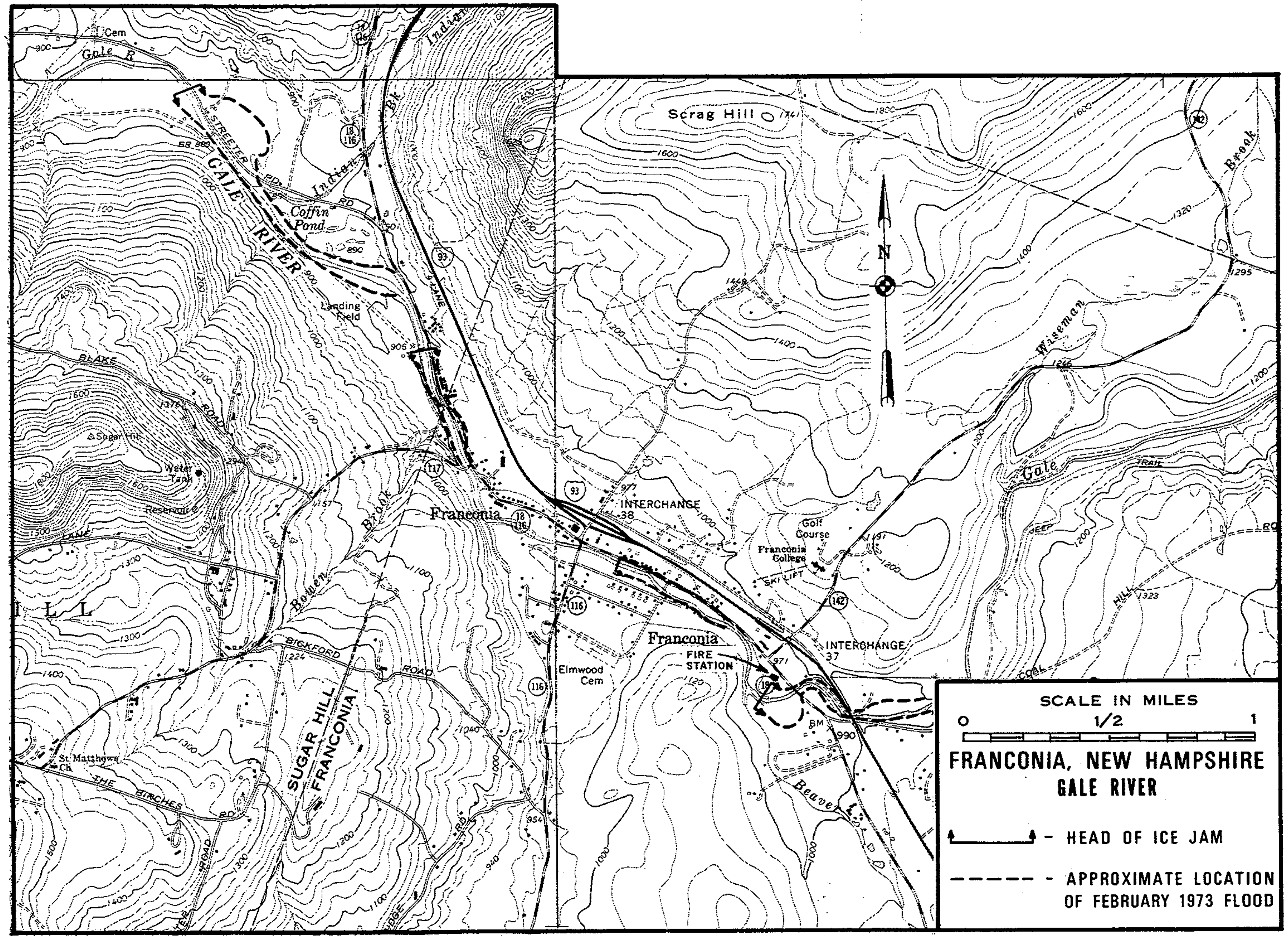
Mechanical removal of the ice at this site has been successful in relieving flooding at this site.

On the Pemigewasset River, the source of ice is the solid cover on the upstream reaches of the Baker and Pemigewasset Rivers. The break up of the upstream ice is the combination of a slight thaw which weakens the ice and an increase in streamflow (due to rainfall) which has an uplifting force on the ice cover. The ice breaks into blocks of varying sizes, the average being 15′x15′x2′. The break up of ice jams on the Baker and upstream reaches of the Pemigewasset River contribute to the problems in Plymouth-Holderness.

The ice jams on a sand bar 1/2-mile downstream of Bridge Street which connects Plymouth and Holderness. The jam extends upstream past Bridge Street and ice hits the low steel of the bridge, threatening it with structural damage. The bridge is closed, resulting in a 12 mile detour. In Holderness, the Plymouth State College Field House (which is flood-proofed), 30 homes and 12 commercial buildings, all located on either River Road or Bridge Street are flooded.

This ice jam remains in place until it melts or until pressure from water and upstream ice force the jam to break up. Downstream of the jam, a second ice jam forms at a sand bar at the Ashland Golf Course. The Ashland jam prevents the jam in Plymouth-Holderness from breaking up and moving downstream.

The towns of Plymouth and Holderness are both in the emergency phase of the National Flood Insurance Program. Additionally, a Flood Hazard Analysis has been published by the Soil Conservation Service delineating the 10, 100, and 500-year floods. Presently neither community has any regulations concerning development in these flood plains.



SCALE IN MILES
0
1/2
1
FRANCONIA, NEW HAMPSHIRE
GALE RIVER
- HEAD OF ICE JAM
- APPROXIMATE LOCATION OF FEBRUARY 1973 FLOOD
Scrag Hill
GALE RIVER
Coffin Pond
Landing Field
Sugar Hill
Water Tank
Franconia
INTERCHANGE 38
INTERCHANGE 37
Golf Course
Franconia College
FIRE STATION
Elmwood Cem
SUGAR HILL
FRANCONIA
St. Matthews Ch
N

PLATE 19

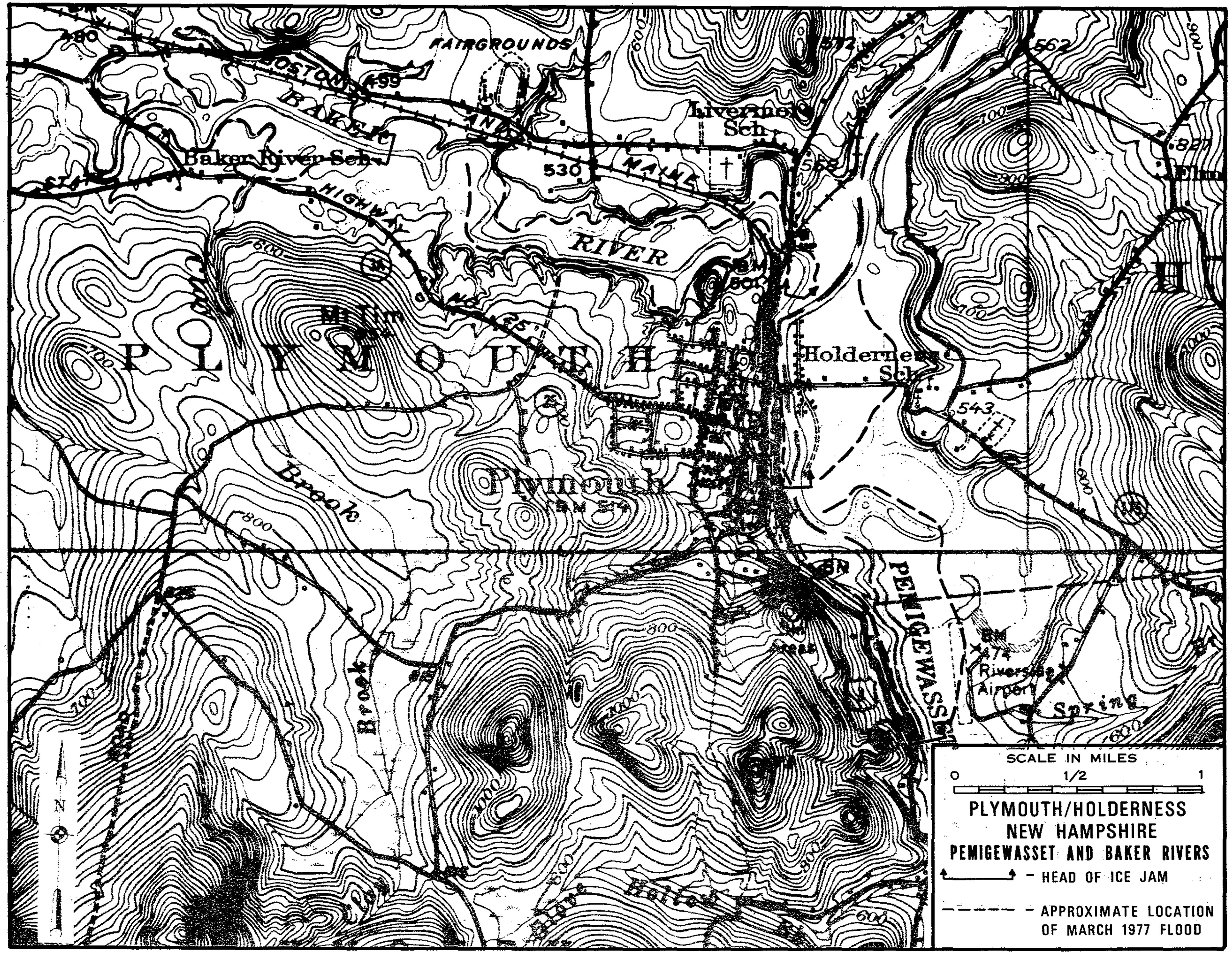

FAIRGROUNDS
BOSTON AND MAINE
BAKER RIVER
Baker River Sch.
HIGHWAY
Livermore Sch.
Holderness Sch.
PLYMOUTH
Plymouth
Brook
PEMIGEWASSET
Riverside Airport
Spring
SCALE IN MILES
0
1/2
1
PLYMOUTH/HOLDERNESS
NEW HAMPSHIRE
PEMIGEWASSET AND BAKER RIVERS
– HEAD OF ICE JAM
– APPROXIMATE LOCATION OF MARCH 1977 FLOOD

PLATE 20

Saco River
North Conway
Contact Dana Webster, North Conway Water Precinct 10 June 1980

In each of the past eleven years, ice jams, usually occurring during a mid-winter thaw in January, have caused flooding on the Saco River in North Conway. The source of ice is the solid ice cover upstream on the Saco River. The breakup of the upstream ice is the combination of a slight thaw which weakens the ice and an increase in streamflow (due to rainfall) which has an uplifting force on the ice cover. The ice breaks into blocks of varying sizes, the average being 15′ x 15′ x 1-1/2′, and moves downstream until it jams at one of the sharp bends of the winding Saco River. The ice usually jams at a point 300′ upstream of the North Conway #2 pumping station. The sand bars in this area contribute to the slow down and grounding of the ice. The jam remains in place until it melts, or until pressure from water and upstream ice force the jam to breakup. Flood damages at this site are minor, only open fields, the pumping station which is flood proofed and portions of a roadway are inundated.

The town is in the regular phase of the National Flood Insurance Program and has adopted FEMA′s minimum regulations restricting development in the 100-year flood plain.

Souhegan River
Milford
Contact: Robert Courage, Superintendent of Public Works 5 August 1980

Every year since 1970, ice jam floods on the Souhegan River have caused problems in Milford. The source of ice is the solid ice cover on the upsteam reaches of the Souhegan River. The break up of the upstream ice is the combination of slight thaw which weakens the ice and an increase in streamflow (due to rainfall) which as an uplifting force on the ice cover. The ice breaks into blocks of varying sizes, the average being 6′x6′x2′ and moves downstream where it jams in two locations. In the center of Milford, the dam completely restricts the flow of the larger ice blocks and a 750-foot jam forms. Further upstream, near the Milford Drive-In Theater, the sharp bend and gravel shoal in the river cause and ice jam which extends upstream approximately 1 mile. The jam remains in place until it melts or until pressure from water and upstream ice force the jam to break. Downstream ice jams occur in the town of Merrimack.

In January 1978, the town of Milford experienced the worst ice jam in eleven years. The Milford Drive-In Theater was compeltely inundated by the flood waters. The O-K Tool Company suffered basement flooding and the Milford Mobile Home Trailer Park was inundated, but the elevated trailers were just above the floodwaters.

The town of Milford is in the regular phase of the National Flood Insurance Program and has adopted FEMA′s minimum regulations restricting development in the 100-year flood plain.

Souhegan River and Baboosic Brook
Merrimack
Contact: Ed Blaine, Director Merrimack Public Works 28 May 1980

In nine of the past eleven years, ice jams, occurring in the spring, have caused flooding on the Souhegan River and Baboosic Brook in Merrimack.

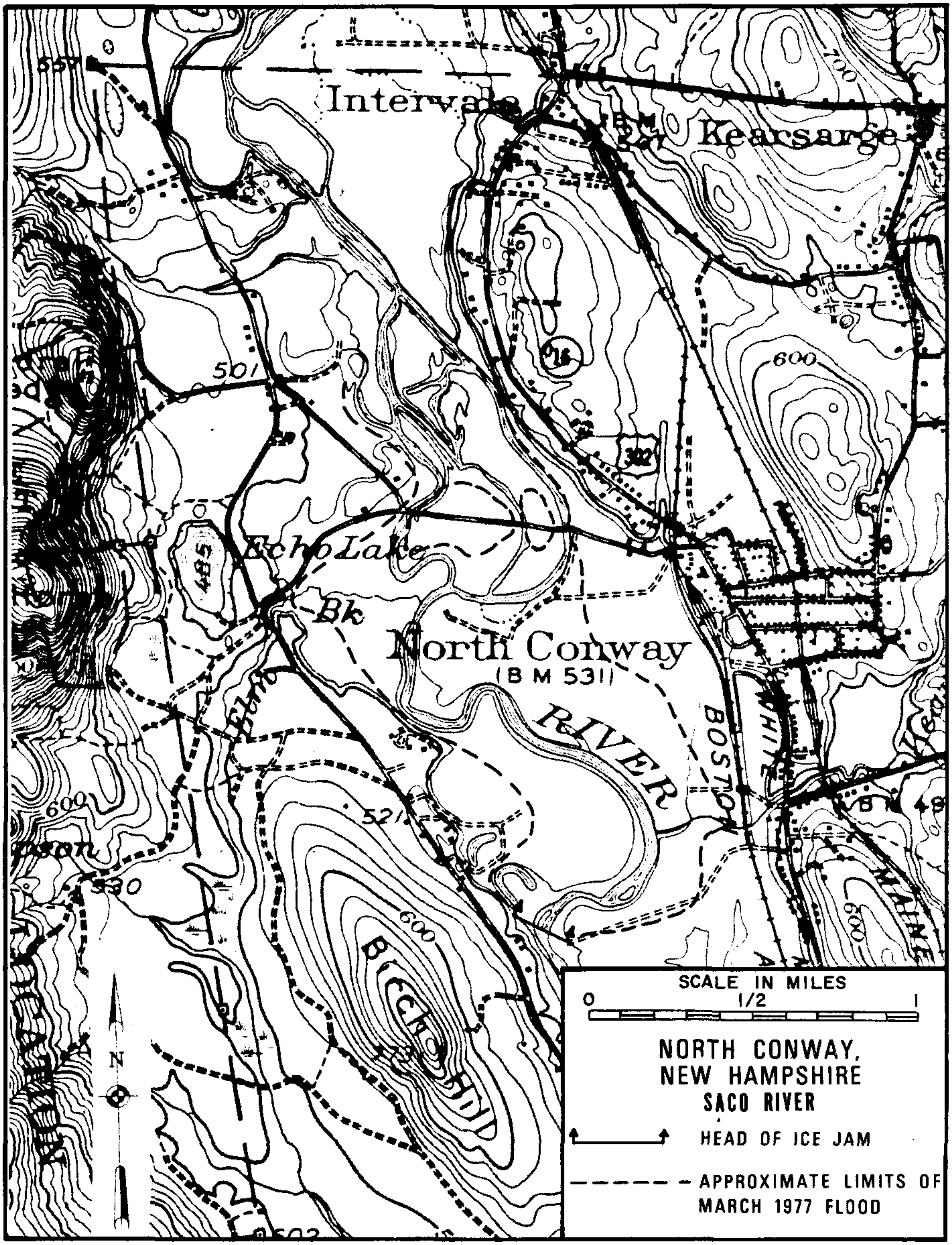
On the Souhegan River the source of ice is the elease c˝ jams further upstream in the town of Milford. The size of the ice cakes vary, the largest being 20'x20'x 1-1/2'. The jam occurs at one of the oxbows in the Souhegan River, approximately 8,000 feet upstream of the F.E. Everett Turnpike Bridge over the Souhegan. The jam extends 2,500 feet upstream and causes flooding to 5 homes on Beacon Drive. The only action the town has taken to date is sandbagging at the homes on Beacon Drive and at culverts along Beacon Drive to prevent further backwater flooding. The jam remains in place until it melts, or until pressure from water and upstream ice force the jam to break up. Downstream of the ice jam, the Souhegan flows freely and once the jam breaks up, it moves downstream without further jamming.

Two ice jams occur annually on Baboosic Brook. Both jams caused damage to roadways and bridges and no structures are inundated. The source of ice is the solid ice cover upstream on Baboosic Brook. The break up of the upstream ice is the combination of a slight thaw which weakens the ice and an incease in streamflow (due to rainall) which has an uplifting force on the ice cover. The ice breaks into blocks of varying sizes, the largest being 15' x15' x1-1/2', and moves downstream until jamming at one of the two sites.

The first jam occurs at the Twin Bridge Road bridge over Baboosic Brook and fills a field upstream of the bridge. In the previous years the jam caused the bridge to be temporarily closed. The bridge has been permanently closed since March 1977 when an ice jam caused excessive damage to the deck and abutments. It is estimated that it will cost $80,000 to replace the bridge. During the March 1977 ice jam, the town attempted to remove the ice using a backhoe, but were unsuccessful because of the large quantity of ice.

The second ice jam on Baboosic Brook occurs at the oxbows 1/2 mile upstream of the F.E. Everett Turnpike bridge over Baboosic Brook. The jam causes water to back up 1/2 mile and flood New Bedford Road. This causes a detour of approximately 3 miles for emergency vehicles.

The town of Merrimack is in the regular phase of the National Flood Insurance Program and has adopted FEMA's minimum regulations restricting development in the 100-year flood plain.



Intervale
Kearsarge
700
600
501
302
16
Echo Lake
485
Bk
North Conway
(B M 531)
RIVER
BOSTON
WHITE
MAINE
600
521
530
600
Birch Hill
N
SCALE IN MILES
0
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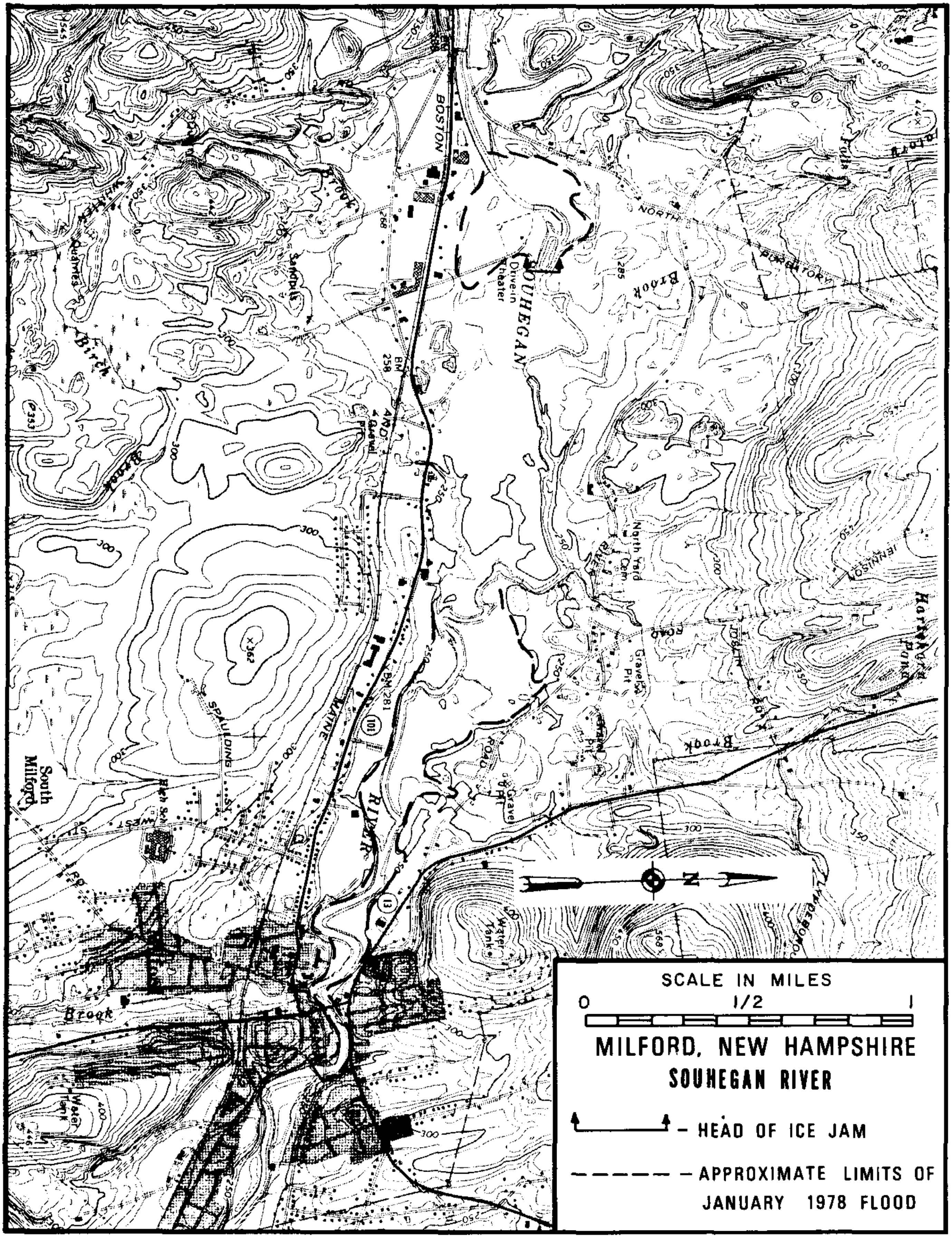
NORTH CONWAY,
NEW HAMPSHIRE
SACO RIVER
HEAD OF ICE JAM
APPROXIMATE LIMITS OF
MARCH 1977 FLOOD

PLATE 21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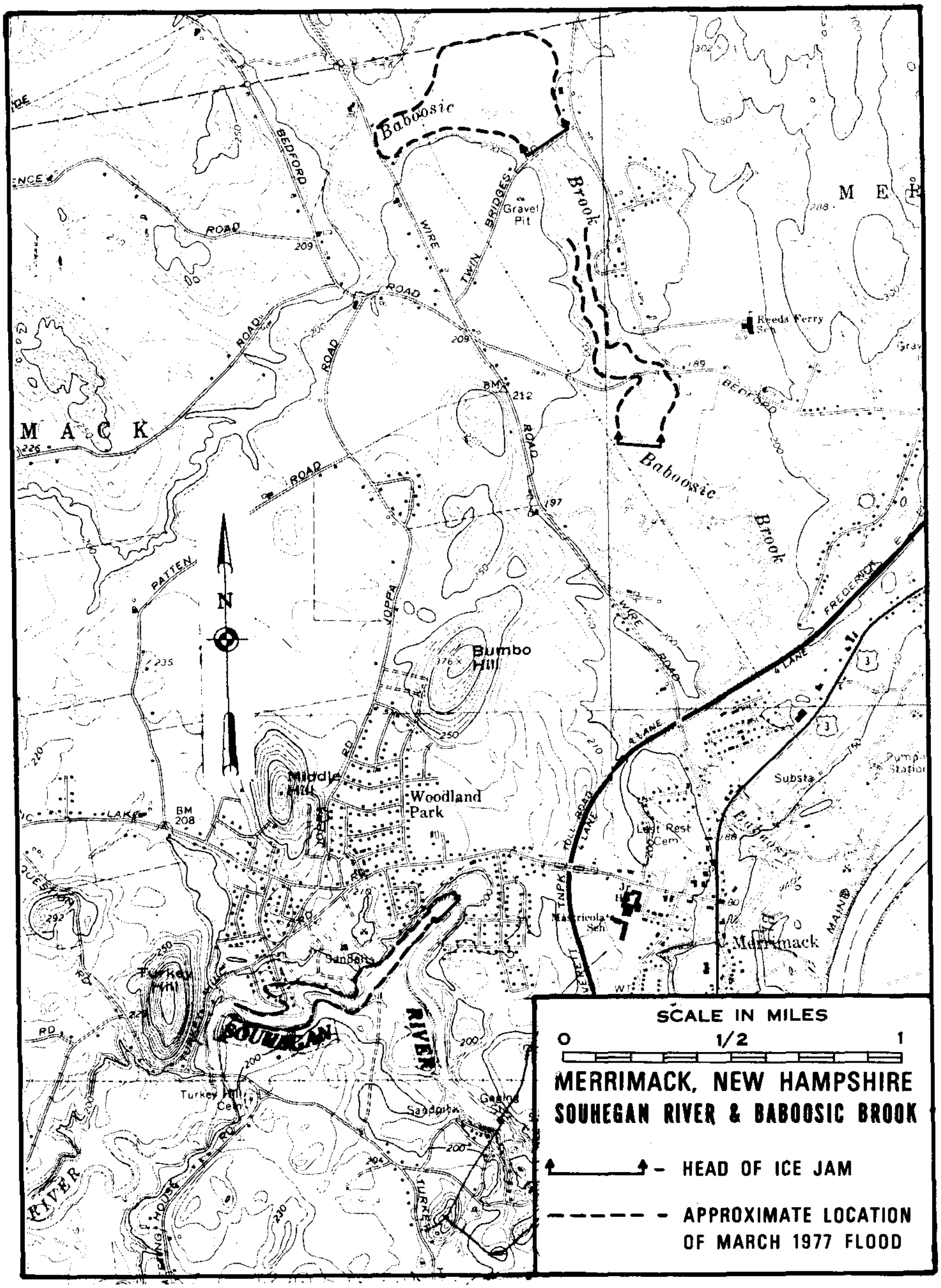
MILFORD, NEW HAMPSHIRE
SOUHEGAN RIVER
– HEAD OF ICE JAM
– APPROXIMATE LIMITS OF JANUARY 1978 FLOOD
N



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MERRIMACK, NEW HAMPSHIRE
SOUHEGAN RIVER & BABOOSIC BROOK
HEAD OF ICE JAM
APPROXIMATE LOCATION OF MARCH 1977 FLOOD
Baboosic
Brook
Baboosic
Brook
Bumbo Hill
Middle Hill
Woodland Park
Turkey Hill
SOUHEGAN
RIVER
Reeds Ferry Sch
Gravel Pit
Last Rest Cem
Mastricola Sch
Merrimack
Turkey Hill Cem
Substa
Pump Station
BEDFORD
WIRE
TWIN BRIDGES
ROAD
PATTEN
JOPPA
LAKE
BM 208
BM 212
N

Suncook River
Allenstown and Pembroke
Contacts: Roger Letendre, Allenstown Civil Defense Director
Larry Young, Pembroke Civil Defense Director 9 June 1980

In eight of the past eleven years, ice jams, usually occurring in February or March have caused flooding on the Suncook River in Allenstown and Pembroke. The source of ice is the solid cover on the upstream reaches of the Suncook River. The break up of the upstream ice is the combination of a slight thaw which weakens the ice and an increase in streamflow (due to rainall) which has an uplifting force on the ice cover. The ice breaks into blocks of varying sizes, the average being 20'x20'x3'. The ice jams at three specific spots on the Suncook. The farthest upstream is at a small abandoned dam approximately 400 feet downstream of the Route 28 bridge. Although the jam forms at the dam, several other conditions immediately upstream contribute to the build up of ice at this site. An island, an abandoned bridge and the abutments of the Route 28 bridge which is located at a bend in the river are all factors which cause the ice cakes to slow down in this area and eventually jam at the dam. The jam extends from the dam upstream to the Route 28 bridge and remains in place until it melts, or pressure from water and upstream ice force the it to break up. Downstream of the dam, the Suncook flows freely for approximately three miles before another jam forms at an oxbow. The oxbow is the primary cause of the jam, however, there are many large boulders and fallen trees in the river which contribute to the build up of ice at this site. Here too the jam remains in place until it melts or the pressure from water and upstream ice force the jam to break. Downstream of the oxbow, the Suncook flows freely for approximately one mile before ice jams at the Webster Dam near the center of town. Downstream of Webster Dam, the Suncook River has a steep gradient and any ice that breaks free is carried downstream to the Merrimack River without further jamming.

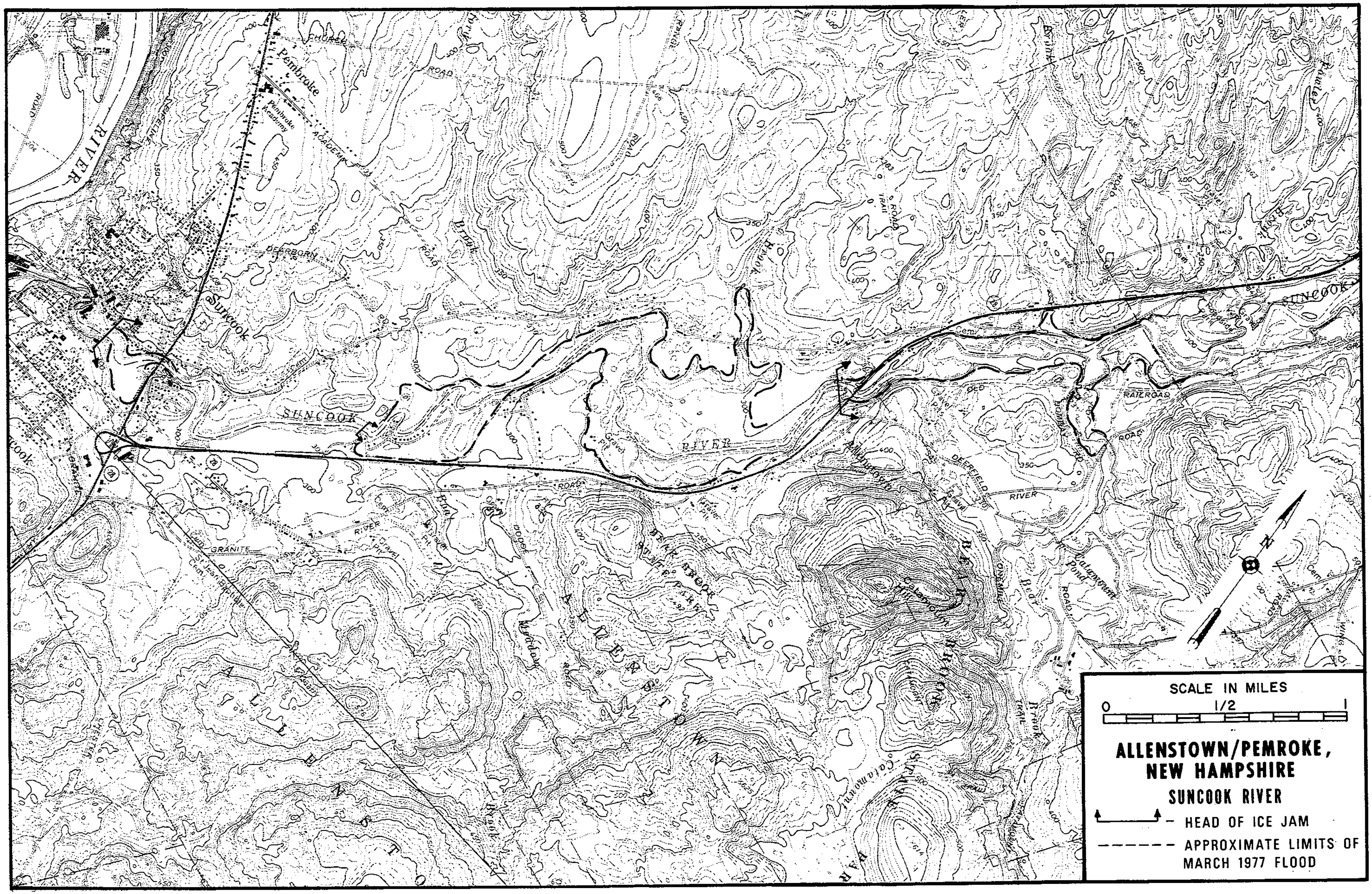
The March 1977 flood was the most severe ice jam flood experienced by Allenstown and Pembroke within the past ten years. During that ice jam event seven residential areas along the Suncook River were flooded.

The jam at Webster Dam caused flooding in Pembroke to eight multiple residence houses on Buck Street near Irish Pond. The majority of flooding in this area was confined to basements and no evacuation was necessary. Portions of Buck Street were also flooded, but the street remained passable.

The jam at the oxbow which is approximately 7,000 feet upstream of the Route 3 Bridge caused flooding in three residentiial areas in Allenstown. The Riverside Park area located between Route 28 and the Suncook River was the hardest hit. This area was originally used for summer camps and cottages, and approximately 15 seasonal structures have been converted and are now occupied year-round. In addition to the older buildings there are approximately 40 newer and larger homes along the river. During the March 1977 event the houses in this section were flooded, with water in most first floors 1-3 feet deep. Over 40 families were evacuated and the only road servicing the area was impassable. Approximately 4,500 feet upstream of the oxbow in the section of Allenstown known as Pine Acres, 7 houses were flooded, but no evacuation was necessary. Approximately 12,700 feet upstream of the oxbow, the water was 3 feet deep at the Brookside Trailer Park in Allenstown and residents of 10 trailers had to be evacuated.

The ice jam at the small abandoned da_ app.oximately 400 feet downstream of the Route 28 bridge caused flooding to 2 homes in Pembroke located adjacent to the dam. This jam also resulted in the flooding and evacuation of over 50 trailers in the Maple Grove Trailer Park in Pembroke. Approximately 7,000 feet upstream of the jam, near the Pembroke/Epsom town line, 3 houses on Old Buck Road were flooded and evacuated. Old Buck Road was inundated in many areas, but still passable.

Both Pembroke and Allenstown are in the regular phase of the National Flood Insurance Program and Pembroke has adopted FEMA's minimum regulations regarding development within the 100-year flood plain, but Allenstown has no flood plain zoning.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ALLENSTOWN/PEMROKE, NEW HAMPSHIRE
SUNCOOK RIVER
HEAD OF ICE JAM
APPROXIMATE LIMITS OF MARCH 1977 FLOOD
SUNCOOK
RIVER
ALLENSTOWN

APPENDIX C

APPENDIX C
VERMONT LOCAL INTERVIEWS

Black River
Cavendish VT
Contact: Rolf Von Shaik, Town Manager 8 July 1980

In each of the past eleven years, ice jams, have caused flooding on the Black River. The source of ice is the solid ice cover upstream on the Black River. The break up of the upstream ice is the combination of a slight thaw which weakens the ice and an increase in streamflow (due to rainfall) which has an uplifting force on the ice cover. The ice breaks into blocks of varying sizes, the average being 10′ x 10′ x 2′. Additionally, ice jams in Ludlow may release, contributing to the ice jams in Cavendish. The January 1976 and March 1977 events were the most severe ice jam floods experienced by Cavendish within the past eleven years. In both cases, ice jammed at three specific sites.

An ice jam occurred at the railroad bridge near the intersection of Routes 103 and 31. This jam extended upstream for 600 feet and flooded Route 103, causing it to be closed.

Midway between Proctorsville and Cavendish a second jam formed at an abandoned dam. This jam extended upstream for 1,000 feet and caused farmland to be flooded and streambank erosion along Route 134. Additionally, six structures on Railroad Street were inundated, but suffered little damage.

A third ice jam occurred at an island 900 feet upstream of the hydroelectric dam in Cavendish. The jam extended upstream for 1,000 feet and caused flooding to two homes on Gulf Road. Ice reached the Gulf Road bridge and residents feared that it would cause serious damage the bridge.

Backhoes, draglines and blasting have all been successfully used in clearing the ice jams.

Cavendish is in the emergency phase of the National Flood Insurance Program and has no flood plain regulations.

Black River
Ludlow
Contact: Dean Brown, Town Manager 8 July 1980

Ice jams on the Black River have threatened the town of Ludlow three out of the past eleven years. The source of ice is the solid ice cover upstream on the Black River. The breakup of the upstream ice is the combination of a slight thaw which weakens the ice and an increase in streamflow (due to rainfall) which has an uplifting force on the ice cover. The ice breaks into blocks of varying sizes, the average being 5′ x 5′ x 2′ and moves downstream until jamming on the sand and gravel bars downstream of the sewage treatment plant. The jam extends upstream 600 feet. It frees itself when warmer temperatures or backwater pressure loosen the ice. Once the jam breaks, the ice blocks flow downstream to Proctorsville and Cavendish where potential for further ice jamming exists.

No structures are directly affected or receive damage as a result of ice jam flooding. However, potential for serious flood damages exists. The January 1976 ice jam posed the greatest threat of flood damages, but the jam broke up before the river could overflow its banks.

Both the town and village of Ludlow are in the regular phase of the National Flood Insurance Program and have adopted FEMA's regulations restricting development in the 100-year flood plain.

Connecticut and Ottauquechee Rivers
Hartford
Contact: Ralph Lehman, Town Manager 23 July 1980

Every year for the past eleven years, ice jams have caused flooding on the Connecticut and Ottauquechee Rivers in Hartford, Vermont. The source of ice is the solid ice cover on the rivers' upstream reaches. On the Ottauquechee, the breakup of the ice is the combination of a slight thaw which weakens the ice and an increase in streamflow (usually due to rainfall) which has an uplifting force on the ice cover. On the Connecticut River, the periodic releases of Wilder Dam upstream increase the streamflow and cause the break up of the solid ice cover. The ice breaks into blocks of varying sizes, the average being 10' x 10' x 2' and jams at two sites on the Connecticut and one site on the Ottauquechee.

The first ice jam is at a gravel bar at the confluence of the Mascoma with the Connecticut River. This jam extends upstream to the Wilder Hydroelectric Dam and causes flooding to two commercial structures.

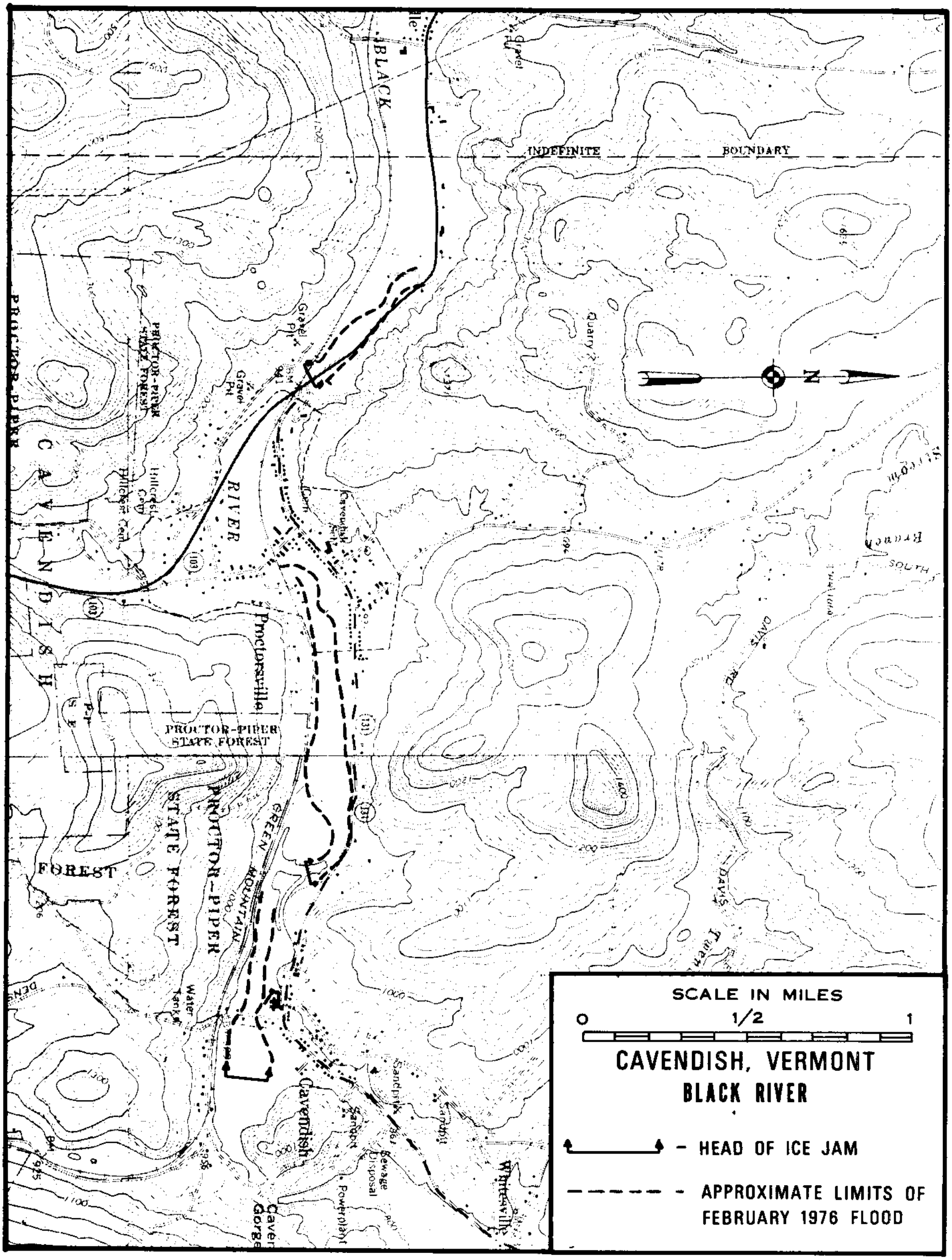
A second ice jam occurs at a bend in the Connecticut River just downstream of the Route I-89 bridge. This jam extends past the mouth of the White River and causes ice to backup along the White River for 8 miles, flooding four homes in the White River Junction area.

The February 1970 ice jam was the worst at this site within the past eleven years and the Corps of Engineers under PL 99 was successful in breaking up this jam using explosives. Downstream, jams frequently cause flooding in the town of Windsor, Vermont.

An ice jam forms on the Ottauquechee River at an abandoned dam near the River Street bridge. The jam extends one mile upstream and causes flooding to two homes. Downstream, there are no ice jams on the Ottauquechee, but jams do occur further downstream on the Connecticut River.

The Corps of Engineers, under Section 205, completed channel improvements on the White River in 1970. These improvements have prevented the formation of ice jams in the White River.

Wilder Dam, on the Connecticut River, releases large volumes during peak electrical demand periods. These sudden releases of water have had a surging effect and have broken up several ice jams on the Connecticut River.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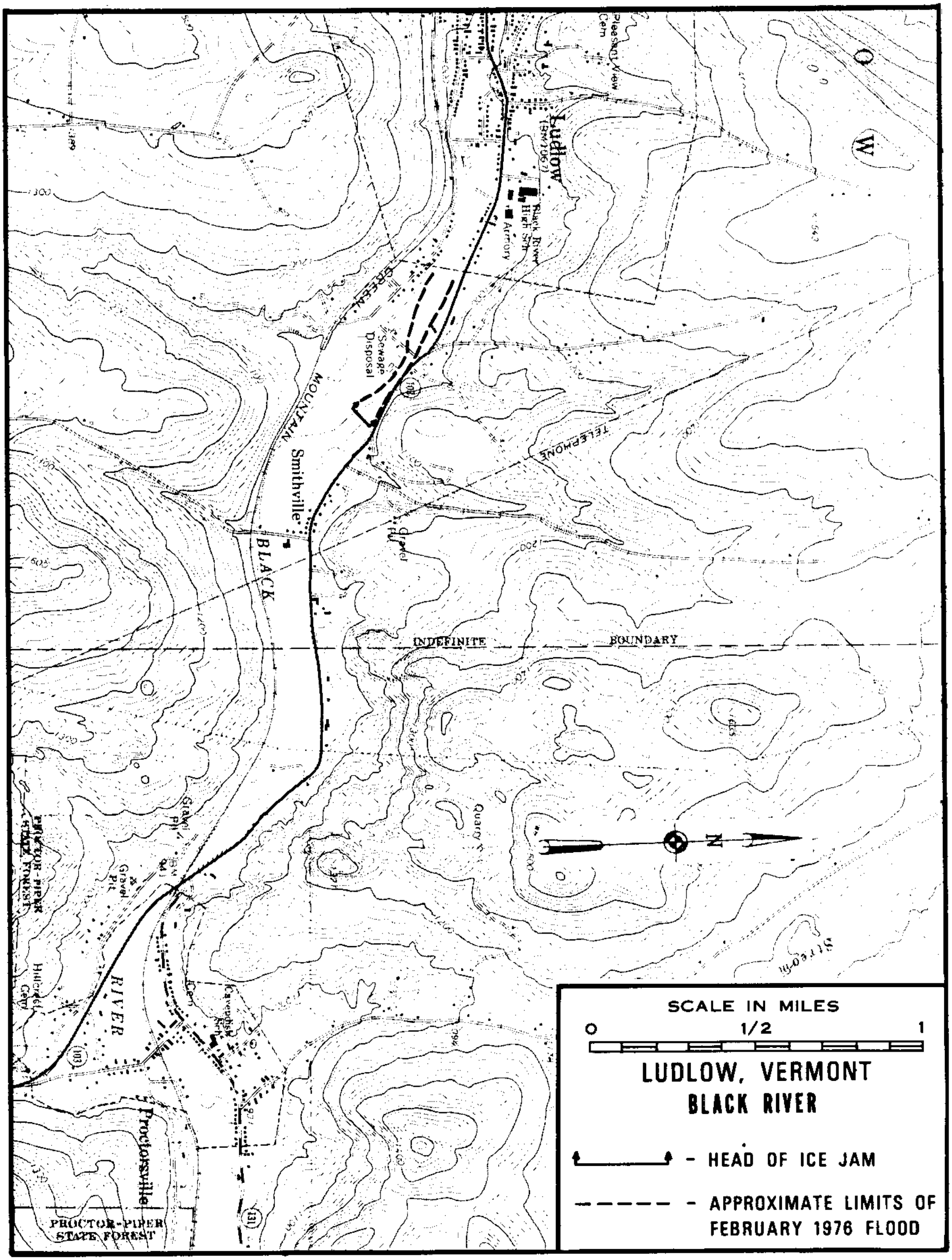
CAVENDISH, VERMONT
BLACK RIVER
- HEAD OF ICE JAM
- APPROXIMATE LIMITS OF FEBRUARY 1976 FLOOD
INDEFINITE BOUNDARY
BLACK
RIVER
PROCTOR-PIPER STATE FOREST
Proctorsville
STATE FOREST
PROCTOR-PIPER
FOREST
GREEN MOUNTAIN
Cavendish
Whitesville
Quarry
Water Tank
Sewage Disposal
Powerplant

PLATE 25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LUDLOW, VERMONT
BLACK RIVER
- HEAD OF ICE JAM
- APPROXIMATE LIMITS OF FEBRUARY 1976 FLOOD
Ludlow
Black River High Sch
Armory
Sewage Disposal
GREEN MOUNTAIN
Smithville
BLACK
RIVER
TELEPHONE
INDEFINITE
BOUNDARY
Quarry
Gravel Pit
Proctorsville
PROCTOR-PIPER STATE FOREST
N

PLATE 26

The town of Hartford is in the regular phase of the National Flood Insurance Program and has adopted FEMA's regulations restricting development in the 100-year flood plain.

Connecticut River
Windsor
Contact: David Stammers, Windsor Fire Chief 9 July 1980

Since 1970, ice jams have caused flooding on the Connecticut River in Windsor in February 1970, 1973 and March 1979. Small jams occur annually and have the potential to develop into full scale jams like those in 1970 1973 and 1979. The source of ice is the solid ice cover upstream on the White River and the reach of the Connecticut River between Windsor and Wilder Dam. Once, in 1970, blasting of a jam upstream at the White River Junction, Vermont, released eight miles of jammed ice which added significantly to the flood problems in Windsor. Locals believe that the breakup of the solid ice cover on the Connecticut River is caused by the periodic release of water from Wilder Dam 15.5 miles upstream. This increase in streamflow on the Connecticut has an uplifting force on the ice cover, causing its breakup. The ice breaks into block of varying sizes, some of them as large as 100' x 60' x 2', and moves downstream until it hangs up at sandbars below the village of Windsor. There are three specific areas where sandbars cause the ice to jam. Each of these areas has been the cause of ice jams. The first is approximately 1,500' upstream of the Windsor Airfield, the second is near Horseback Ridge and the third is at Chase Island. The head of the jam has been at each of these sandbars, but most frequent is the site near Horseback Ridge. The jam extends up past the village of Windsor to Sumner Falls in Hartland, Vermont. The jam remains in place until it melts, or until pressures from water and upstream ice force the jam to breakup. Downstream of the Windsor Airfield, the Connecticut flows freely and once the jam breaks up, it moves downstream without further jamming.

The March 1979 flood was the most severe ice jam flood experienced by Windsor within the past ten years. During that ice jam event, 6-8 houses were flooded, 4 retail stores were inundated, the town sewage treatment plant and pumping stations were flooded, and portions of Route 5, the town's main thoroughfare were indunated, causing detours of 2-3 miles for emergency vehicles. Because the sewage treatment plant was flooded, the town was forced to dump its raw sewage into the Connecticut River. The covered bridge which crosses the Connecticut River and joins Windsor to Cornish, New Hampshire, was closed and ice was jammed up against the bridge. Most of the lower wood siding was ripped off by the ice.

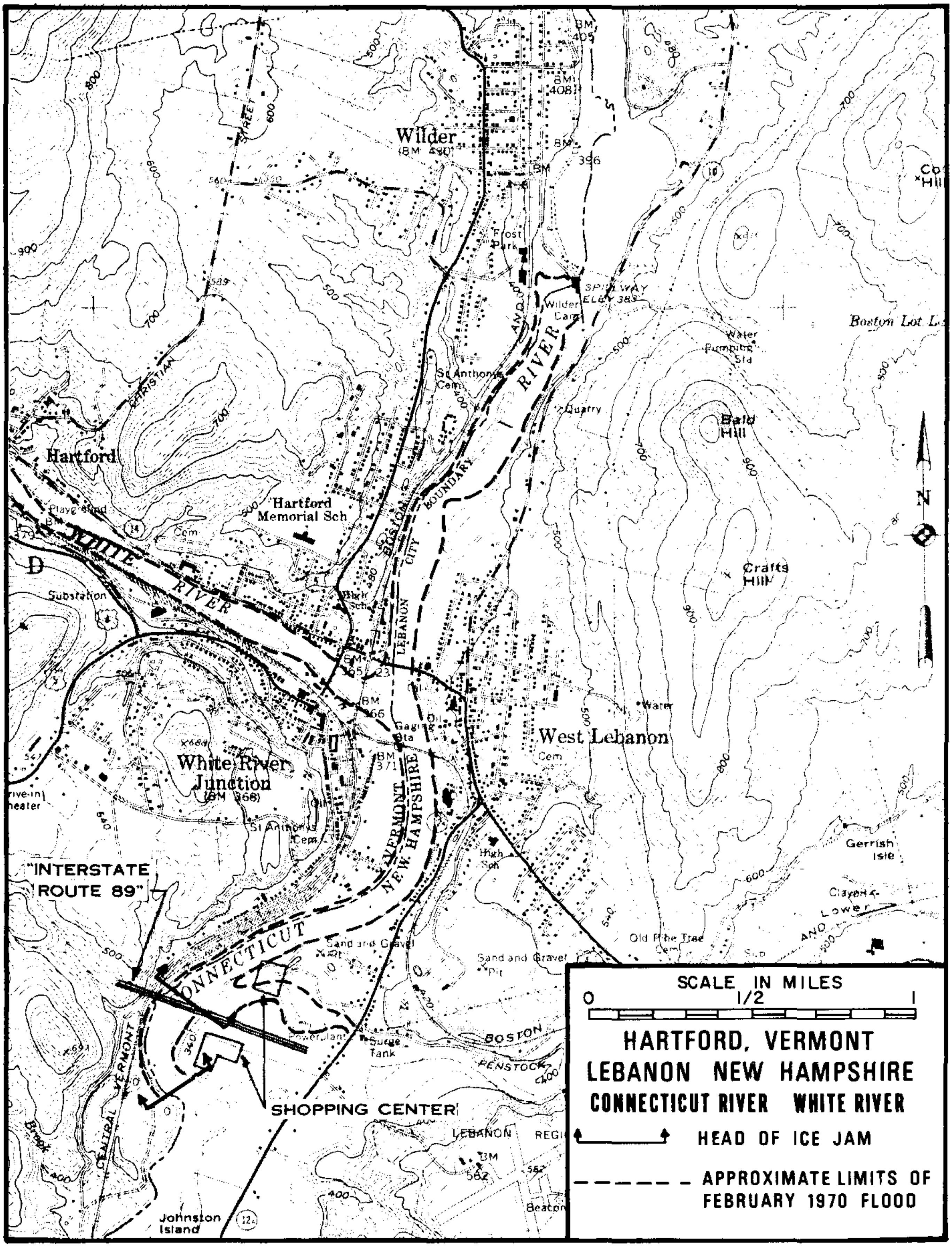
Because ice jam flooding is a frequent occurrence, residents and local officials are prepared to take steps to minimize the effects of flooding. The town monitors the ice jam and the level of the river. When the river begins to rise the motors are removed from the pumping stations at the sewage treatment plant. Town employees and volunteers have sandbagged the Grand Union shopping plaza (containing four stores) in the past and the complex is now almost totally floodproofed. In the March 1979 flood although the plaza was inundated, the buildings sustained little flood damage. Surrounding communities are on call to provide emergency service to areas which are isolated by the flooding of Route 5. Local officials have been effective in preventing damage to the sewage treatment plant and the shopping plaza, but so far, they have not had enough time to prevent damage to the 6-8 houses which are inundated. Although the sewage treatment plant is not physically damaged by the flood waters, it is inoperative and the community is forced to dump raw sewage into the Connecticut River. The covered bridge has experienced minor structural damage in the past and there is the potential for more serious structural damage in the future.

The town is in the regular phase of the National Flood Insurance Program and consequently, the town zoning regulations restrict development in the flood plain. However, it should be noted that some areas outside the 100-year flood plain delineated on Flood Insurance Rate Maps may be subject to ice jam flooding, particularly along Jarvis Street which has approximately 50 homes. This street runs parallel with the river and although it has not been flooded in recent ice jams, the ice has been as high as the homes, and the potential for flooding due to ice jams is a concern in this area.

First Branch White River
Tunbridge
Contact: Alvin Tuller, Tunbridge Civil Defense Director 8 July 1980

In eight of the past eleven years, ice jams, usually occurring in March or April, have caused flooding on the First Branch White River in Tunbridge. The source of ice is the solid ice cover upstream on the First Branch White River. The breakup of the upstream ice is the combination of a slight thaw which weakens the ice and an increase in streamflow (due to rainfall) which has an uplifting force on the ice cover. The ice breaks into blocks of varying sizes, the average being 10′ x 10′ x 2′, and moves downstream until it hangs up at several sites along the First Branch White River. There are three abandoned dams and several oxbows which are the usual areas for the ice jams. Trees present another obstacle to the ice. First Branch White River is a winding stream, and trees have been planted along the banks in an effort to prevent erosion of valuable farmland. This measure retards the erosion, but is not completely effective, and as the streambank slowly erodes, the trees fall into the river and increase the potential for ice jamming.

The first ice jam occurs at an oxbow approximately 1-1/2 miles downstream of Tunbridge Fairgounds. There are usually fallen trees at this oxbow, which contribute to the ice jamming. The jam extends upstream for approximately one mile. This jam caused flooding at the Tunbridge Fairgrounds and although there was little damage to the buildings on the fairgounds, several of the structures are used for winter storage of farm equipment, which was damaged. The ice was jammed to the deck of a covered bridge, tearing off some the lower sideboards, and threatening more severe damage. Fields were also flooded, causing erosion to valuable farmland.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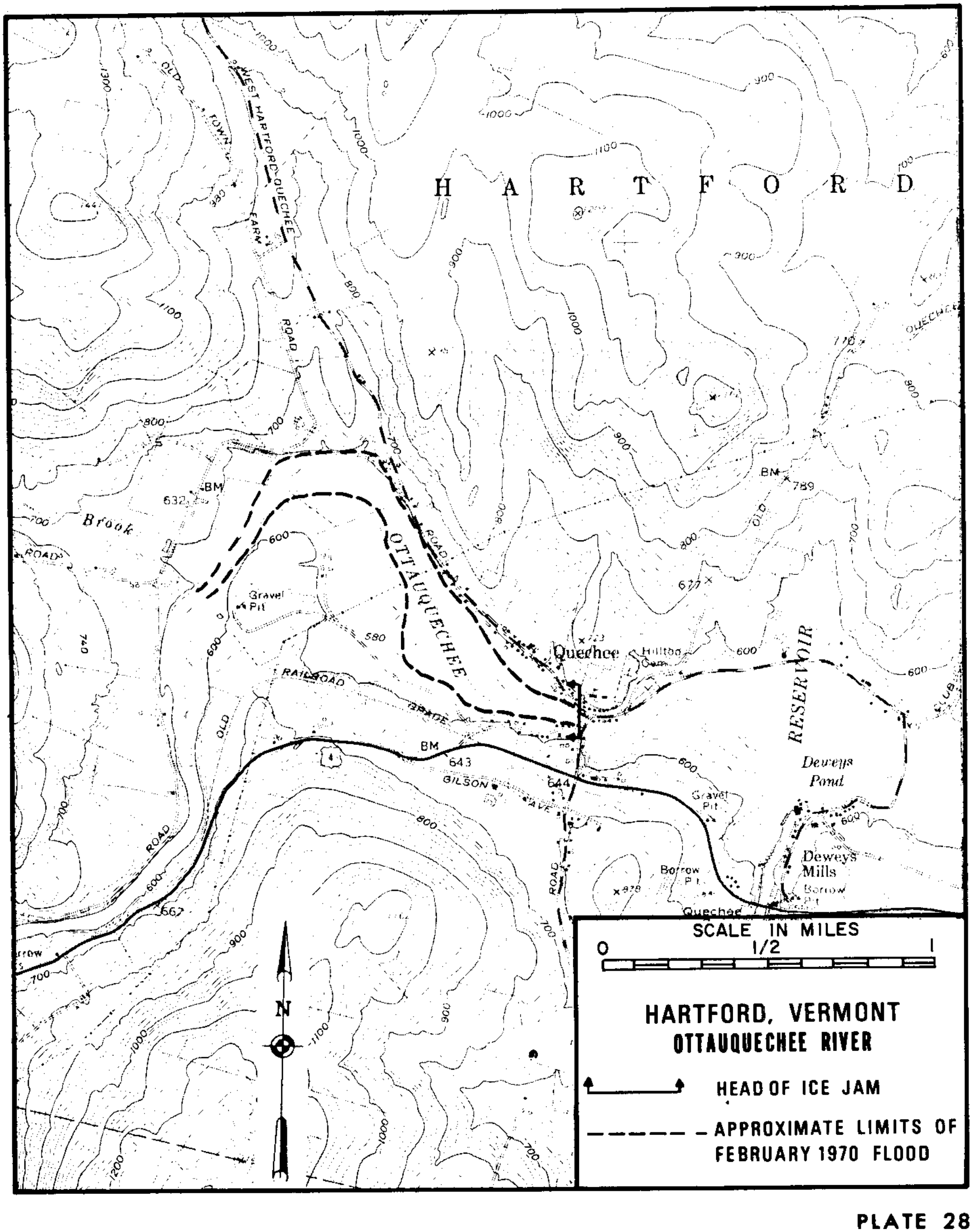
HARTFORD, VERMONT
LEBANON NEW HAMPSHIRE
CONNECTICUT RIVER WHITE RIVER
HEAD OF ICE JAM
APPROXIMATE LIMITS OF FEBRUARY 1970 FLOOD
"INTERSTATE ROUTE 89"
SHOPPING CENTER
Wilder
Hartford
White River Junction
West Lebanon
Hartford Memorial Sch
WHITE RIVER
CONNECTICUT
RIVER
VERMONT
NEW HAMPSHIRE
LEBANON CITY BOUNDARY
BOSTON AND
Wilder Dam
SPILLWAY ELEV 385
Bald Hill
Crafts Hill
Gerrish Isle
Johnston Island
Boston Lot
Quarry
Substation
BOSTON PENSTOCK
Sand and Gravel Pit
Old Pine Tree Cem
Surge Tank
N

PLATE 27


HARTFORD
OTTAUQUECHEE
RESERVOIR
Deweys Pond
Deweys Mills
Quechee
Brook
WEST HARTFORD-QUECHEE ROAD
OLD TOWN FARM ROAD
RAILROAD GRADE
GILSON AVE
Gravel Pit
Borrow Pit
SCALE IN MILES
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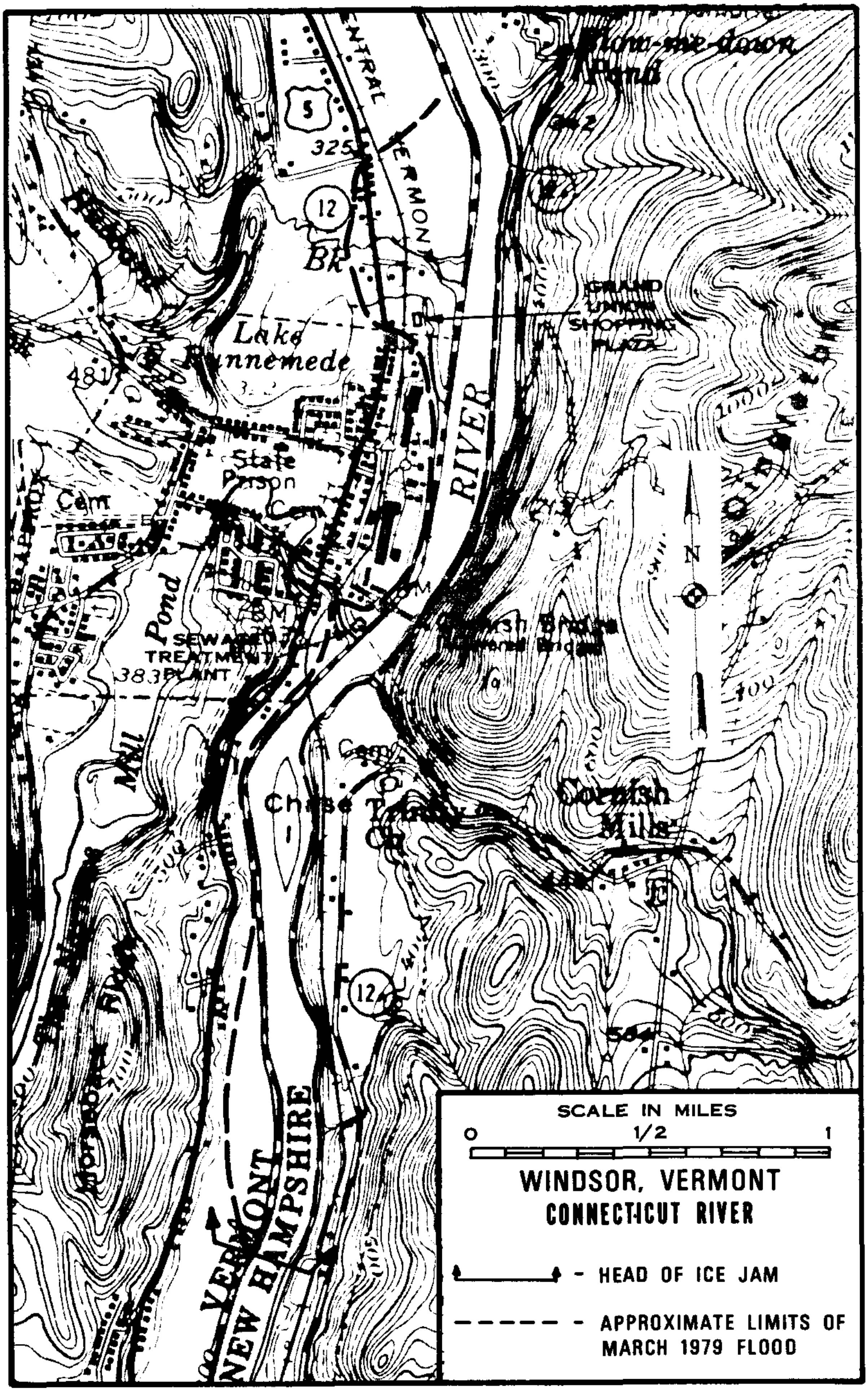
HARTFORD, VERMONT
OTTAUQUECHEE RIVER
HEAD OF ICE JAM
APPROXIMATE LIMITS OF FEBRUARY 1970 FLOOD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WINDSOR, VERMONT
CONNECTICUT RIVER
HEAD OF ICE JAM
APPROXIMATE LIMITS OF MARCH 1979 FLOOD
Lake Runnemede
State Prison
Mill Pond
SEWAGE TREATMENT PLANT
RIVER
Cornish Mills
VERMONT
NEW HAMPSHIRE
N

A second ice jam forms at a sharp bend in the river just upstream of the Tunbridge Fairgrounds. Rocks and debris contribute to the formation of ice jams in this area. The jam extends approximately 1 000 feet upstream to an abandoned dam just upstream of the covered bridge in Tunbridge Village. This jam causes minor basement flooding and damage to the siding of the covered bridge. More serious damage to the bridge is a threat.

A third ice jam occurs at an abandoned dam 1-1/2 miles upstream of North Tunbridge and extends upstream for approximately one mile. This jam causes minor basement flooding and the inundation of Route 110, the town's major thoroughfare, isolating approximately 25 homes. In February 1976, the State Highway Department used a dragline to remove the ice along Route 110.

Tunbridge is in the emergency phase of the National Flood Insurance Program and has no regulations restricting flood plain development.

Lamoille and Brewster Rivers
Cambridge
Contact John Raymond, Civil Defense Director 22 July 1980

In nine of the past eleven years, ice jams usually occurring in January or March, have caused flooding on the Lamoille River in Cambridge. Once in the past eleven years, an ice jam caused flooding on the Brewster River in the village of Jeffersonville within the town of Cambridge.

The source of ice for the jam on the Lamoille is the solid ice cover on the Brewster River and upstream reach of the Lamoille River. The breakup of the upstream ice is the combination of a slight thaw which weakens the ice and an increase in streamflow (due to rainfall) which has an uplifting force on the ice cover. The ice breaks into blocks of varying sizes, the average being 10′ x 10′ x 2′, and moves downstream until it grounds at a sharp bend of the river at Cambridge, approximately 1,200 feet downstream of the Route 15 bridge. The jam extends from the bend upstream for approximately 1/2-mile, with much of the ice being deposited in open fields upstream of the Route 15 bridge. The jam remains in place until it melts or until pressure from water and upstream ice force the jam to breakup. Downstream of the bend, the Lamoille flows freely and once the jam breaks up, it moves downstream without further jamming.

The Lamoille River ice jam, in addition to causing the Lamoille to overflow its banks, results in the backup and flooding of the Seymour River. A service station, a recreational building belonging to the American Legion, 12 homes, open fields and portions of Route 15 are flooded almost annually. The flooding of Route 15 isolates approximately 30 homes north of Cambridge Village.

Flood damages caused by the ice jam on the Lamoille River are fairly consistent from year to year, however, the February 1976 ice jam on the Brewster River combined with the jam on the Lamoille River to cause the worst ice jam flood experienced by Cambridge within the past eleven years. The ice jam on the Brewster occurred at the Route 15 bridge over the Brewster River and extended approximately 2,000 feet upstream. In addition to the bridge and its single pier acting as obstructions the capacity of the left channel was reduced by a gravel bar and debris, causing the ice to jam.

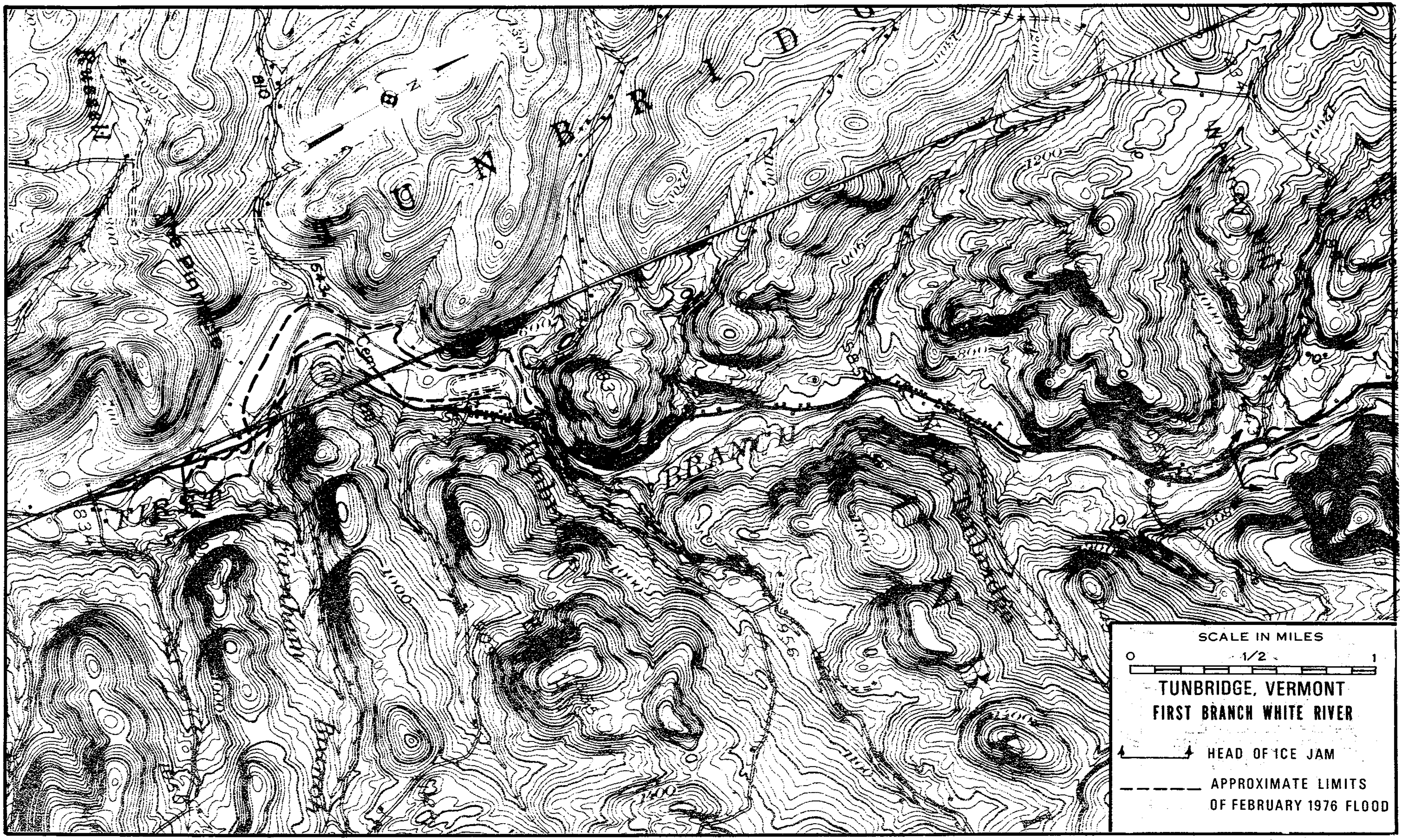
The jam caused flooding to 15 homes and a tennis camp, including dormitories and indoor courts. The town used a shovel dozer to remove the ice from the Brewster. This action relieved the flooding and also prevented the ice from moving downstream and creating further problems at the Lamoille River ice jam.

Because of frequent ice jam flooding along the Lamoille approximately 12 homeowners have floodproofed their homes, by moving furnaces and utilities out of their basements and to elevations above past high water. These measures have minimized much of the flood damages to homes. The town is in the emergency phase of the National Flood Insurance Program and regulates development in the 100-year flood plain as specified by FEMA.

Little River
Stowe
Contact: Giles Dewey, Town Selectman 8 July 1980

In three of the past eleven years, ice jams, usually occurring in March or April have caused flooding on the Little River in Stowe. The source of ice is the solid ice cover upstream on the Little River. The breakup of the upstream ice is the combination of a slight thaw which weakens the ice and an increase in streamflow (due to rainfall) which has an uplifting force on the ice cover. The ice breaks into blocks of varying sizes, the average being 12′ x 12′ x 2′, and moves downstream until it jams at one of the bends in the river between the dam at Moscow and the River Road bridge, the most common site for ice jamming is the bend approximately 1,500′ upstream of the dam at Moscow. The only area flooded by this jam are undeveloped field and, therefore, the jam in this area is allowed to remain in place until it melts, or until pressure from water and upstream ice force the jam to breakup. The Little River flows freely downstream and once the jam breaks up, the ice moves downstream without further jamming.

The ice jam of March 1976 occurred at a bend in the river approximately 1.5 miles upstream of the usual site of the ice jamming. During that ice jam event, the ice was backed up 200 feet upstream of the River Road bridge for a total length of 2,000 feet. The channel was almost completely blocked and the water was flowing over the ice and through a field to the east of the channel below the bridge. For a short time, water overtopped River Road downstream of the bridge. The first level of the Stoweware Canoe Factory (adjacent to the bridge) was flooded. Ice was under the east side of the building and was threatening structural damage. There was no damage to the bridge, however, there was only 4 feet of clearance between the ice and low steel of the bridge where the is normally 14 of feet clearance. The town and State spent approximately $9,000 using a backhoe and bulldozer



SCALE IN MILES
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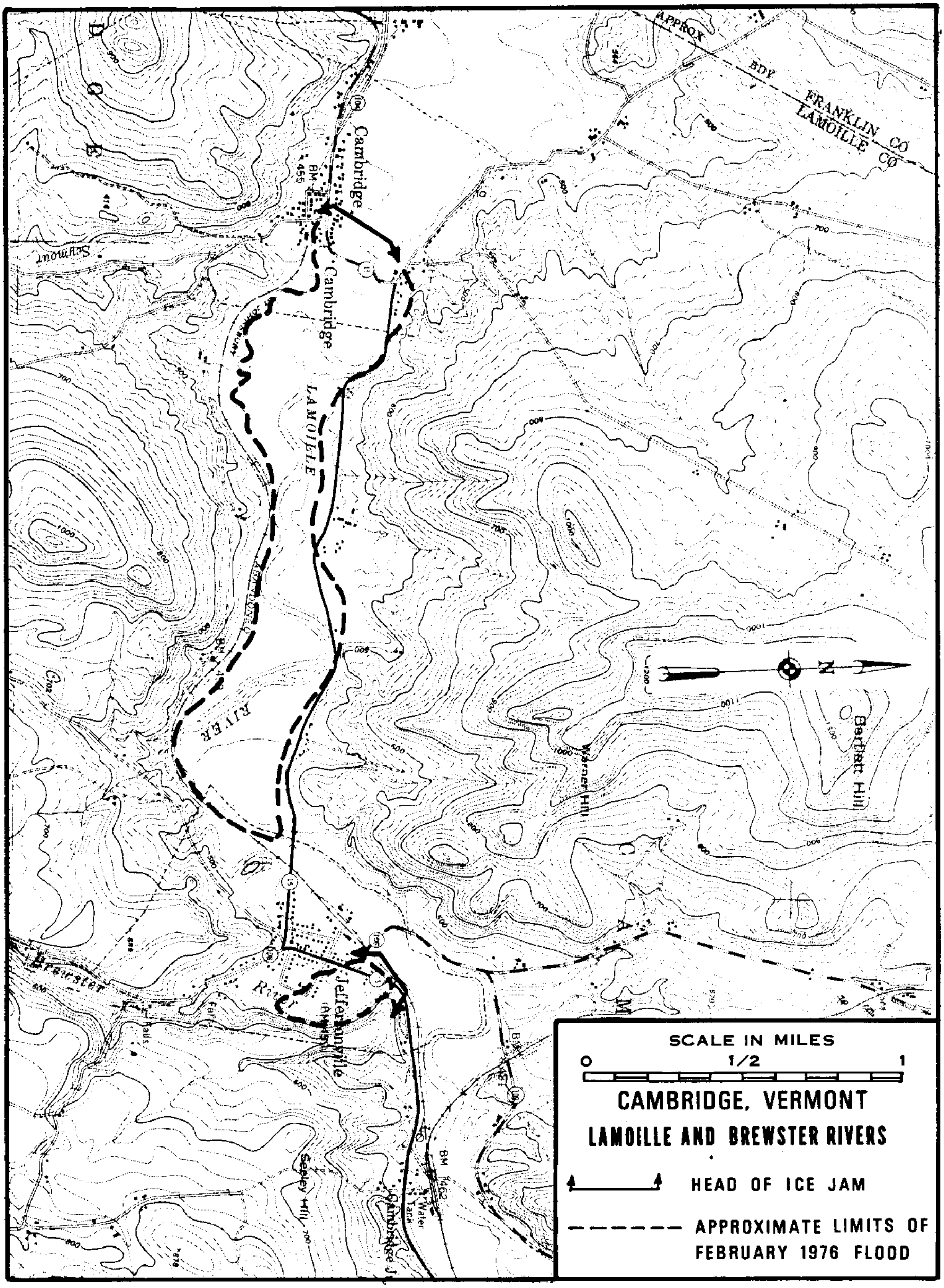
TUNBRIDGE, VERMONT
FIRST BRANCH WHITE RIVER
HEAD OF ICE JAM
APPROXIMATE LIMITS
OF FEBRUARY 1976 FLOOD

PLATE 30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CAMBRIDGE, VERMONT
LAMOILLE AND BREWSTER RIVERS
HEAD OF ICE JAM
APPROXIMATE LIMITS OF FEBRUARY 1976 FLOOD
Cambridge
Cambridge
LAMOILLE
RIVER
Jeffersonville
Brewster
APPROX BDY
FRANKLIN CO
LAMOILLE CO
Warner Hill
Bartlett Hill
Seeley Hill
Water Tank
N

PLATE 31

to remove the ice and relieve the flooding.

Ice jam flooding is a regular occurrence in Stowe, however, the damage is usually minmal because only undeveloped fields are flooded. Stowe is in the regular phase of the National Flood Insurance Program and has adopted FEMA's minimum regulations restricting development in the 100-year flood plain.

North Branch Deerfield River
Wilmington
Contact: Sid Davis, Town Lister 22 July 1980

Ice jams on the North Branch Deerfield River have caused flood damage in Wilmington six of the past eleven years. The source of ice is the solid ice cover upstream on the North Branch Deerfield River. The breakup of the upstream ice is the combination of a slight thaw which weakens the ice and an increase in streamflow (due to rainfall) which has an uplifting force on the ice cover. The ice breaks into blocks of varying sizes, the average being 10' x 10' x 2'. The ice flows downstream and jams at four specific sites:

1. Ice jams at a sharp bend in the river near the Route 100 bridge.
2. Ice jams on a gravel bar behind Ploughman's Rest Lounge.
3. Ice jams in the center of town at the confluence of Beaver Brook.
4. Ice jams at channel constrictions downstream of Beaver Brook.

The February 1973 flood was the most severe ice jam event experienced by Wilmington within the past eleven years. The four ice jams caused flooding to the town offices, library, fire station, seven commercial structures and six homes. The Higley Hill Road bridge was overtopped and Route 9 bridge, which carries and 8-inch water main and an electrical conduit beneath its deck, was threatened by rising ice and water. Total damage for the February 1973 event was estimated to be $40,000. Blasting of these ice jams was successful in relieving the flooding.

Because of the frequent ice jam flooding occurrences in Wilmington, residents and local officials have formulated emergency procedures to deal with this problem. Town officials alert residents of impending flood stages, oil burners and electrical boxes are disconnected in river-abutting structures to prevent possible fires, the fire department pumps water from basements and assists in the evacuation of threatened residents. Fire substations are established a two strategic points in the town to assure townwide fire protection.

Wilmington is in the regular phase of the National Flood Insurance Program and has adopted FEMA's minimum regulations restricting development in the 100-year flood plain.

Miller Run, Sheldon Brook. Branch Brook
Passumpsic East Branch Passumpsic and
West Branch Passumpsic Rivers
Lyndon
Contact: Richard.Lawrence, Lyndon Selectman 21 July 1980

In seven of the past eleven years, ice jams have occurred at seven sites on six streams in the town of Lyndon. However, only the December 1973 and February 1976 ice jam floods posed serious problems for the town. The source of ice is the solid ice cover upstream on Sheldon Brook, Branch Brook, Miller Run and the Passumpsic, East Branch Passumpsic and West Branch Passumpsic Rivers. The breakup of the upstream ice is the combination of a slight thaw which weakens the ice and an increase in streamflow (due to rainfall) which has an uplifting force on the ice cover. The ice breaks into blocks of varying sizes, the average being 10′ x 10′ x 1-1/2′, and moves downstream until it jams at one of the seven sites.

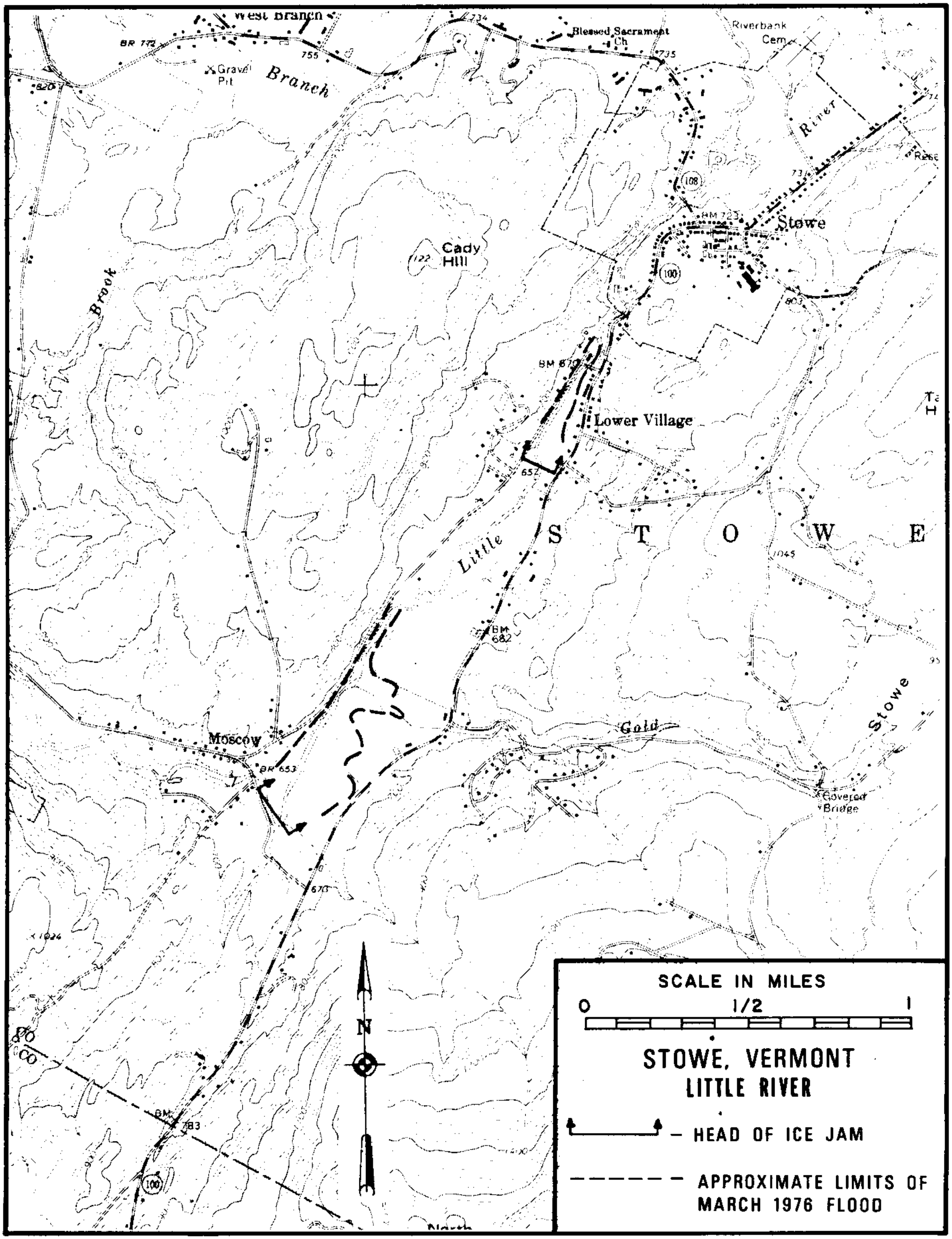
1. An ice jam occurs at the confluence of Sheldon Brook with the Passumpsic River. The jam causes flooding of open fields and the State Aid #2 roadway, causing a two mile detour for the residents of Red Village. This jam is not considered serious and remains in place until it melts, or until pressure from water and upstream ice force the jam to breakup.

2. Ice jams at the Route 5 bridge over the West Branch Passumpsic River and causes Quimley Brook to backup and flood one home. This jam is not considered serious and remains in place until it melts, or until pressure from water and usptream ice force the jam to breakup.

3. Ice jams at the State Aid #26 bridge over Miller Run. This jam causes flooding to four homes, but is not considered serious. It remains in place until it melts, or until pressures from water and upstream ice force the jam to breakup.

4. Ice jams have formed at the State Aid #1 bridge over Branch Brook. The jam flooded six homes, caused the York Street bridge to be impassable and damaged a covered bridge. During the February 1976 ice jam flood, the Corps of Engineers, under PL 99, cleared the channel of ice using a dragline. The town previously used dynamite to clear the channel. Since 1976, the town has cleared debris and gravel deposits from the reach upstream of the State Aid #1 bridge. This has allowed the ice to move freely downstream and only minor jams have occurred at the bridge since the completion of channel work.

5. Ice jams at the Lyndonville Electric Light and Power Company Dam, on the Passumpsic River flooding one commercial building. This jam is not considered serious and remains in place until it melts.



West Branch
Blessed Sacrament Ch
Riverbank Cem
Gravel Pit
Branch
River
Brook
Cady Hill
Stowe
Lower Village
Little
S T O W E
Moscow
Gold
Stowe
Covered Bridge
N
SCALE IN MILES
0
1/2
1
STOWE, VERMONT
LITTLE RIVER
– HEAD OF ICE JAM
APPROXIMATE LIMITS OF MARCH 1976 FLOOD

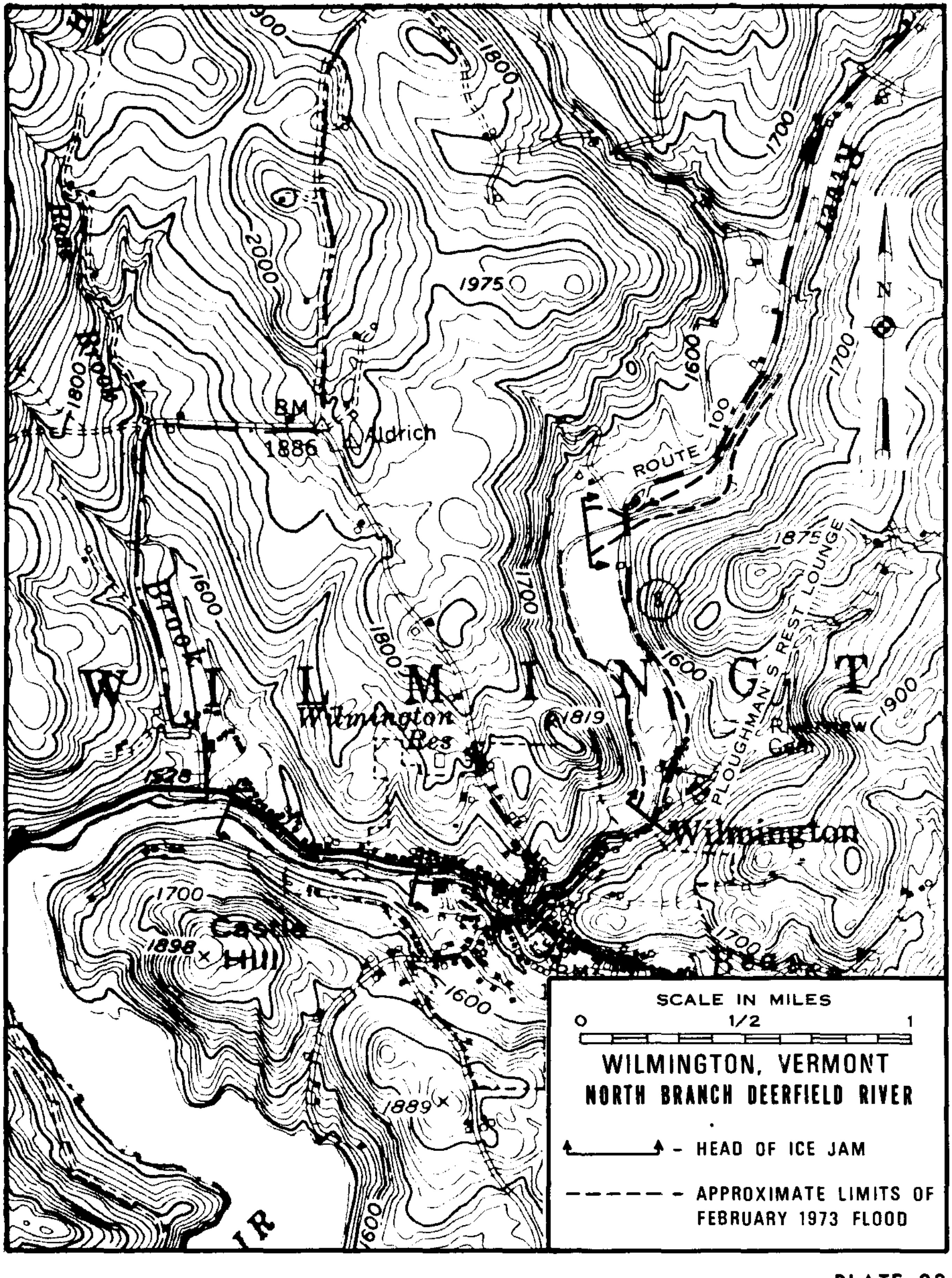

SCALE IN MILES
0
1/2
1
WILMINGTON, VERMONT
NORTH BRANCH DEERFIELD RIVER
- HEAD OF ICE JAM
- APPROXIMATE LIMITS OF
FEBRUARY 1973 FLOOD
ROUTE 100
PLOUGHMAN'S REST LOUNGE
Wilmington
Wilmington Res
Castle Hill
Aldrich
BM
1886
1975
1898
1889
1819
1875
N

PLATE 33

6 Ice jams on the Passumpsic River south the village of Lyndonville at the Route 5 bridge. This jam caused flooding to a motel, but the ground around the motel has been filled and consequently, the motel has not been damaged by recent ice jam floods.

7. One of Lyndon's more frequent and serious ice jams is the jam at a sandbar downstream of the Route 122 bridge over the Passumpsic River. Dead trees and other debris are grounded in the sandbar and present further obstructions to hold the ice. The jam extends approximately 1/2-mile upstream and floods meadowlands, seven homes and Route 122.

8. Lyndon's most serious ice jam occurs at a sharp bend in the Passumpsic River approximately 500' upstream of the mouth of Miller Run. Sandbars and debris contribute to the ice jamming. The jam extends upstream past the Route 114 bridge. Routes 114 and 5, seven homes, three commercial buildings and 50 mobile homes are flooded. In December 1973, the estimated damages totalled over $150,000 for Lyndon residents, and nearly $10,000 for the State. Several remedial actions have been taken to lessen damages due to ice jam flooding. The Northeast Kingdom Mobile Home Park has constructed a dike since the 1973 flood, but it is not tied into high ground, and culverts used for interior drainage are not equipped to prevent the back up of flood waters. Consequently, damages during the February 1976 ice jam flood were comparable to those experienced during the December 1973 event. Efforts were made by the owners of the Lyn-Burke Motel to prevent damages during the December 1973 flood, by building a temporary dike of loose sand, however, flood waters had subsided before work could be completed. In December 1973, under PL 99 the Corps attempted to dislodge the jam at the bend in the river by blasting, with little success. Additionally, many home owners complained of windows being broken by the blasting. A dragline was used to clear the channel downstream of the Lyn-Burke Motel.

Lyndon is in the emergency phase of the National Flood Insurance Program and the Soil Conservation Service has published a Flood Hazard Analysis for the town. There are no regulations restricting development in the 100-year flood plain.

Whetstone Brook
Brattleboro
Contact: Howard Madison, Brattleboro Fire Chief 7 July 1980

In five of the past eleven years, ice jams have caused flooding on Whetstone Brook in Brattleboro. The source of ice is the solid ice cover on the upstream reaches of Whetstone and Halliday Brooks. The breakup of the upstream ice is the combination of a slight thaw which weakens the ice and an increase in streamflow (due to rainfall) which has an uplifting force on the ice cover. The ice breaks into blocks of varying sizes, the average being 20' x 20' x 2'. The ice jams at County Drive bridge and extends upstream for 300 feet. The jam usually remains in place until it melts, or pressure from water and upstream ice force the jam to breakup, however, mechanical removal has been successful at this site. Downstream, Whetstone Brook flows freely through Brattleboro Center to its confluence with the Connecticut River.

Ice jam flooding on the West River was a major problem in the past. However, since the completion the Corps of Engineers' Ball Mountain and Townshend Lake Reservoirs, no flooding damages have been incurred. An ice jam does form at the piers of the railroad bridge at the river's confluence with the Connecticut River, but, no major flooding occurs.

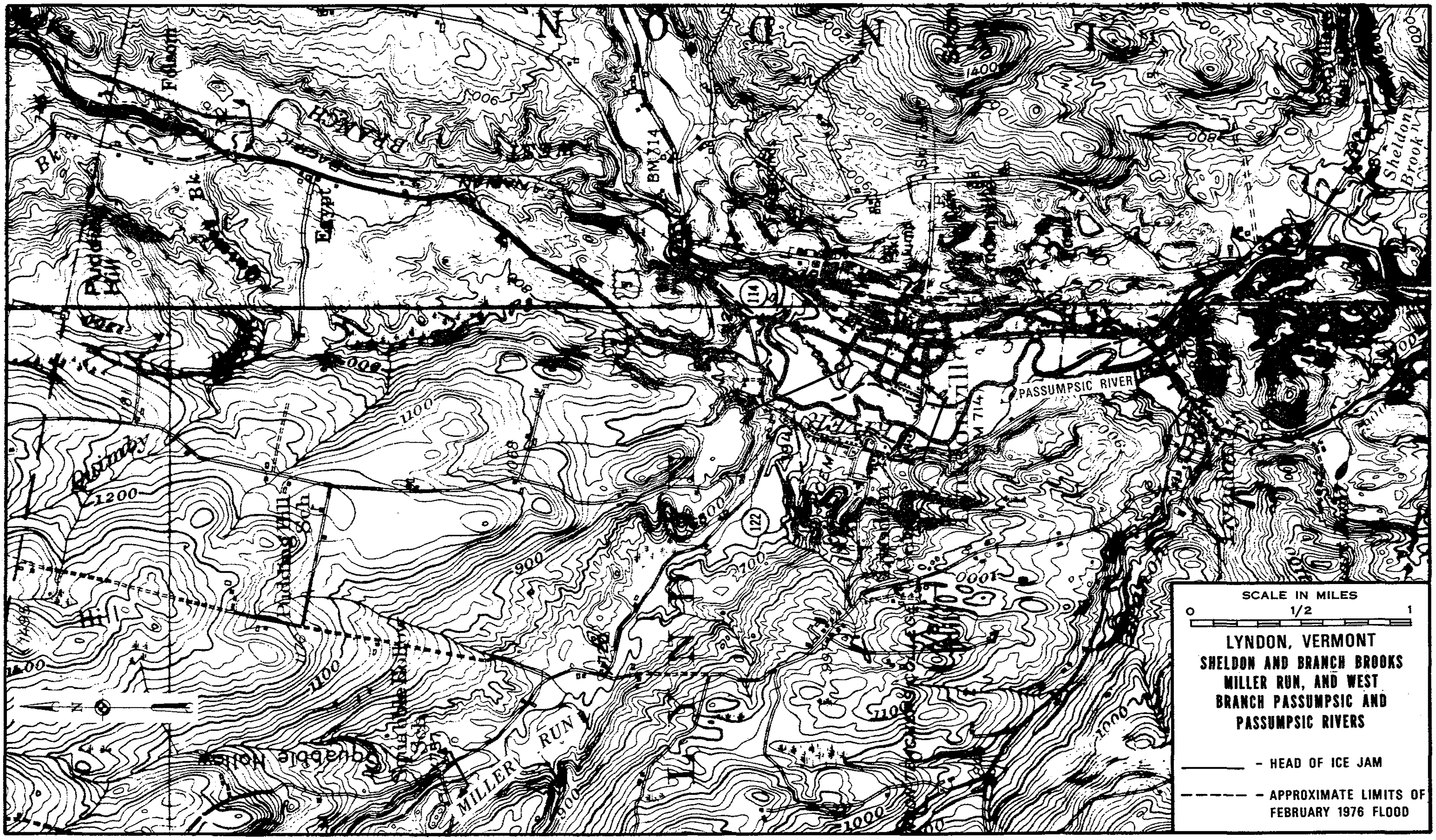
The most significant ice jam event to occur in Brattleboro was in January 1976. The Whetstone overflowed its banks damaging approximately 20 trailers at the Mountain Home Mobile Home Park. Approximately 200 people were evacuated. Sections of Route 9 were inundated and closed.

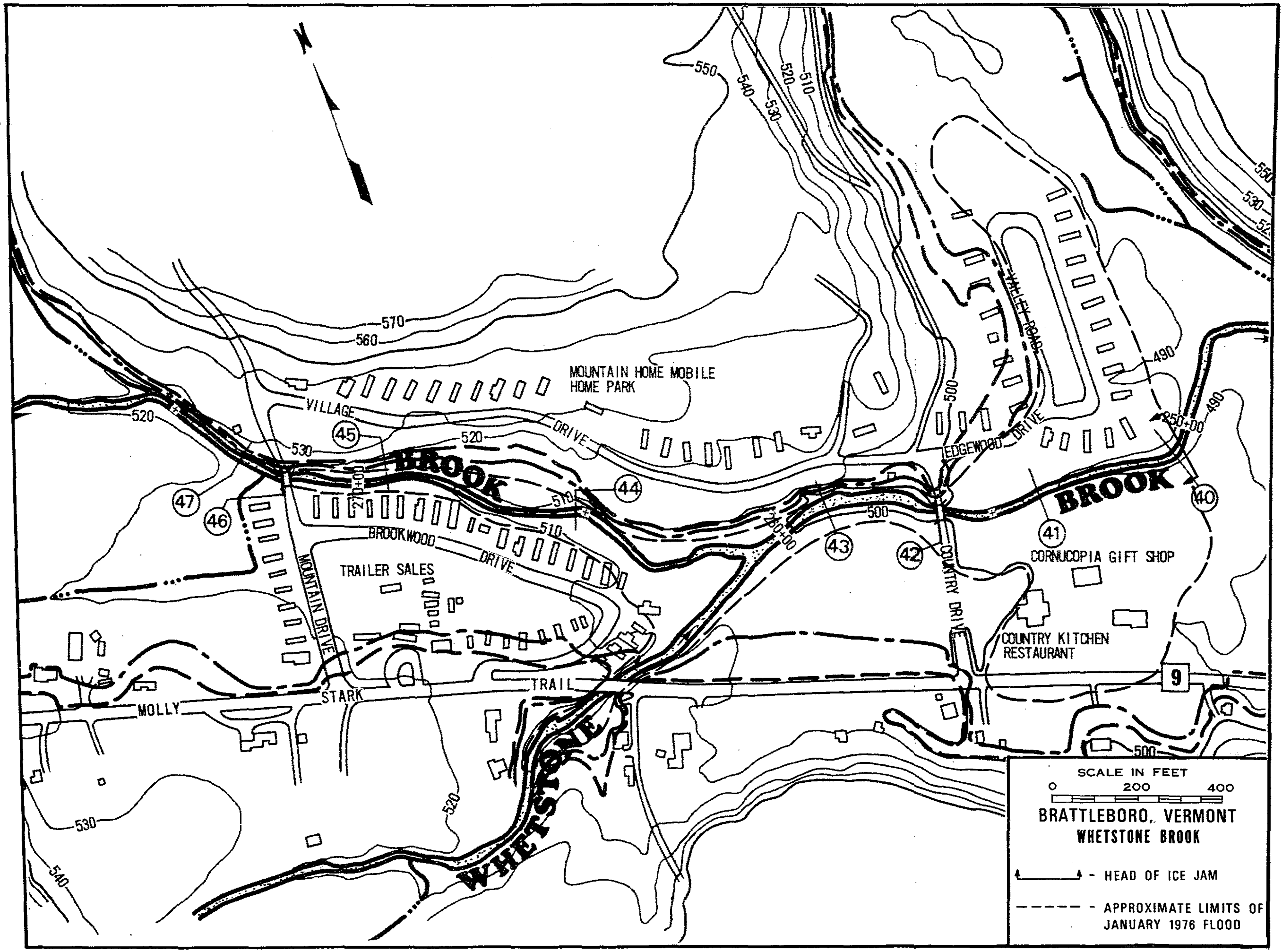
Because of recurring ice jam flooding the town has formulated a detailed emergency plan that has been helpful. The emergency operations headquarters is set up in the police station with communications linking the town manager, fire department, and 4-wheel emergency vehicles. The Town Senior Center is used to house evacuees complete with bedding and food. The fire department also keeps close contact with designated "River Watchers" who monitor flow levels along the brook.

The town is in the emergency phase of the National Flood Insurance Program and has adopted FEMA's minimum regulations restricting development in the 100-year flood plain.

White River
Rochester
Contact: Dean Martin, Rochester Selectman 23 July 1980

In each of the past eleven years, ice jams, usually occurring in January or March have caused flooding on the White River in Rochester. The source of ice is the solid ice cover upstream on the Saco River. The breakup of the upstream ice is the combination of a slight thaw which weakens the ice and an increase in streamflow (due to rainfall) which has an uplifting force on the ice cover. The ice breaks into blocks of varying sizes, the average being 6' x 6' x 1-1/2', and moves downstream until it jams at four specific areas. The first three sites are at bridges and have caused only minor problems in the past. However, when these three jams breakup, they move downstream and form one large jam at an oxbow in the White River, approximately 4,500 feet downstream of the Liberty Hill bridge. The jam extends from the oxbow, upstream for approximately 1-1//2 miles, with much of the ice being deposited on farmland. With the exception of the 1976 ice jam, the jams remain in pace until they melt, or until pressure from water and upstream ice force the jams to breakup. Downstream of the oxbow, the White River flows freely and once the jam breaks up, it moves downstream without further jamming.


SCALE IN MILES
0
1/2
1
LYNDON, VERMONT
SHELDON AND BRANCH BROOKS
MILLER RUN, AND WEST
BRANCH PASSUMPSIC AND
PASSUMPSIC RIVERS
- HEAD OF ICE JAM
- APPROXIMATE LIMITS OF
FEBRUARY 1976 FLOOD
PASSUMPSIC RIVER
MILLER RUN
Sheldon Brook
Squabble Hollow
114
122



MOUNTAIN HOME MOBILE HOME PARK
VILLAGE DRIVE
BROOK
BROOKWOOD DRIVE
TRAILER SALES
MOUNTAIN DRIVE
STARK TRAIL
MOLLY
WHETSTONE
EDGEWOOD DRIVE
VALLEY ROAD
COUNTRY DRIVE
CORNUCOPIA GIFT SHOP
COUNTRY KITCHEN RESTAURANT
9
270+00
260+00
250+00
40
41
42
43
44
45
46
47
SCALE IN FEET
0 200 400
BRATTLEBORO, VERMONT
WHETSTONE BROOK
- HEAD OF ICE JAM
- APPROXIMATE LIMITS OF JANUARY 1976 FLOOD

PLATE 35

The February 1976 flood was the most severe ice jam flood experienced by Rochester within the past eleven years. During that ice jam event, the farm adjacent to the Liberty Hill bridge suffered $20,000 damage. Additionally, 24 families were completely isolated. The lone access to the Mount Reeder and Liberty Hill residential areas are bridges over the White River. Ice jams at each of these bridges caused flooding and approximately 12 families at each area were totally isolated. The Mount Reeder ice jam eventually broke up and moved downstream, however, the Liberty Hill ice jam flooding was alleviated by mechanical means. A dozer and grader opened the access road to the bridge and a clamshell crane removed the jammed ice from upstream of the bridge. Under Public Law 99, the Corps of Engineers provided assistance in this effort.

Ice jam flooding is an almost annual occurrence, however, during the past six years, farmers after receiving State approval, have been removing gravel deposits from the White River. The intent of the farmers is to keep the stream flowing straight and thereby prevent streambank erosion of the farmland. This clearing of the main channel has made it easier for ice flows to move downstream and thereby reduced the intensity of the more recent ice jams. There is little land that is actually flooded, with the exception of one dairy farm which suffers from erosion due to the ice. The main problem is the flooding of the roadway at the bridges to Mount Reeder and Liberty Hill. The Liberty Hill bridge which will be replaced in 1981, has the more frequent and severe problems. In addition to the dairy farmer who must dump his milk because he has no way to get it across the river, 12 families are isolated from the town. There are no structures flooded except for some minor basement flooding.

Rochester is in the emergency phase of the National Flood Insurance Program and has no regulations restricting development in the flood plain.

Williams River, Middle and South Branches Williams River
Chester
Contact: Prentice Hammond, Town Manager 8 July 1980

Every year for the past eleven years, Chester has experienced flooding as a result of ice jams on the three branches of the William River. In all cases, the source of ice is the solid ice cover upstream on the rivers. The breakup of the upstream ice is the combination of a slight thaw which weakens the ice and an increase in streamflow (due to rainfall) which has an uplifting force on the ice cover. The ice breaks into blocks of varying sizes, the average being 10′ x 10′ x 2′.

On the Williams River, the ice jams up at two locations. Approximately one mile north of the village of Gassetts, the ice jams where the river becomes very shallow in an area of extensive gravel deposits. The other location is near Jewett Road. The sharp S-curve in the river causes the ice to lodge in the side of the riverbank. In both of these cases the jam extends upstream for approximately 500 feet.

On the Middle Branch the ice jams at the Joe Swett Road bridge where the river becomes shallow and slow moving.

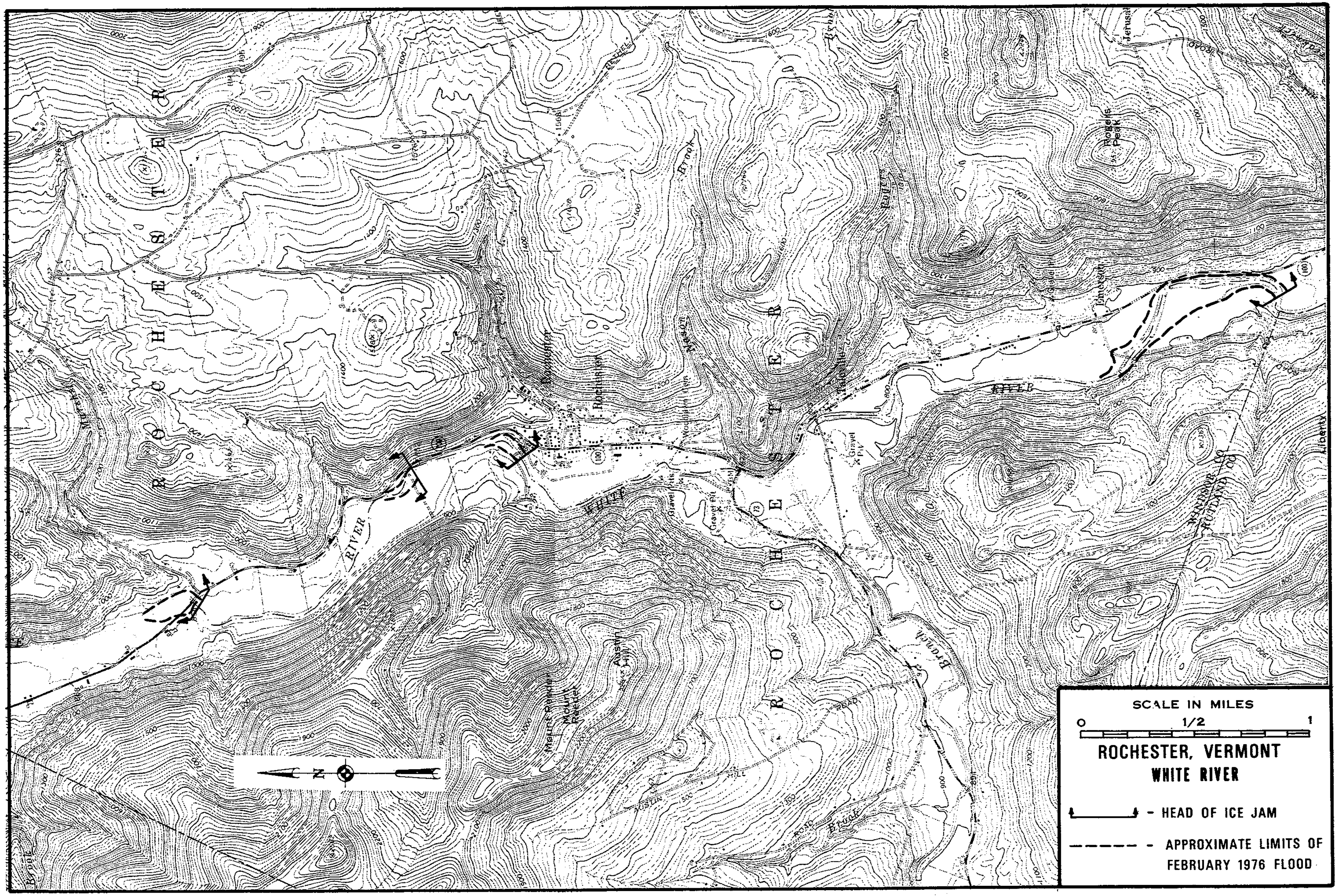
On the South Branch the ice jams at two locations: at the river's confluence with the Middle Branch; and 200 yards upstream of the confluence at the Route 103 bridge. Like the previous jam sites in Chester, both of these are caused by shallow watercourses and gravel deposits in the streambed.

The flood of February 1976 was the most damaging ice jam event within the past eleven years. Altough no structures were directly affected by the flood waters, the flooding did cause some damage. High water on the North Branch isolated three homes on Jewett and Thompson Roads and caused streambank erosion along Route 103. This major thoroughfare was subsequently closed, causing a ten mile detour for emergency vehicles. The Joe Swett Road bridge over the Middle Branch was destroyed, the cost to replace the bridge is estimated to be $70,000. Also erosion along the Middle Branch is threatening of Route 103. One home along the South Branch received basement flooding and the municipal sewer line near Route 103 was subjected to possible ice damage. Also, Town Highway #10, was damaged by erosion.

Several times the town has contracted ice removal work on the three branches and each time the mechanical removal has been successful.

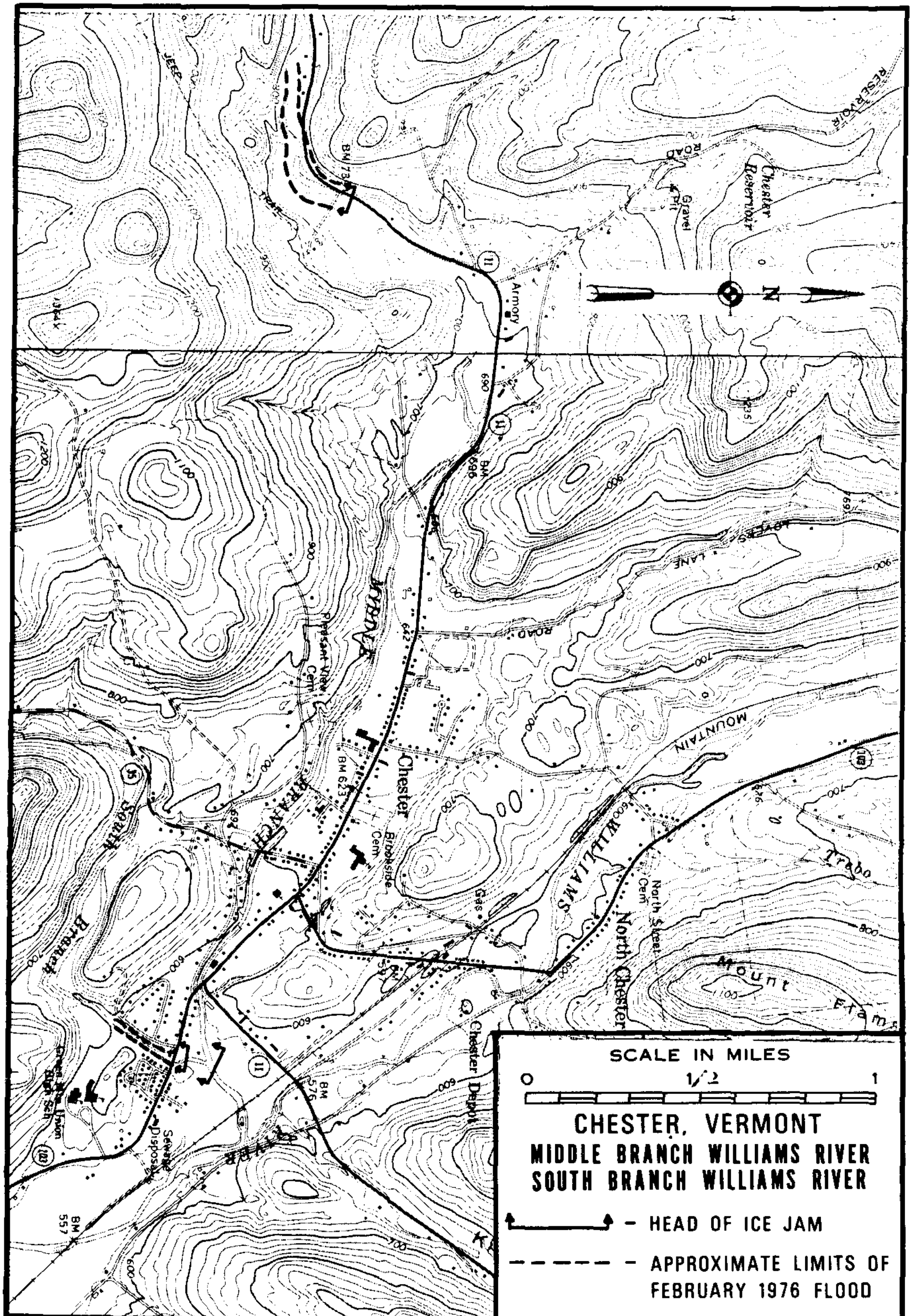
Channel improvements were performed on the Williams River near Gassetts in 1976. The streambed was cleared of the large boulders which were placed along the banks. Since completion of this work, the area has been free of ice jams.

Chester is in the regular phase of the National Flood Insurance Program and has adopted FEMA's minimum regulations restricting development in the 100-year flood plain.



SCALE IN MILES
0
1/2
1
ROCHESTER, VERMONT
WHITE RIVER
- HEAD OF ICE JAM
- APPROXIMATE LIMITS OF FEBRUARY 1976 FLOOD

PLATE 36



SCALE IN MILES
0
1/2
1
CHESTER, VERMONT
MIDDLE BRANCH WILLIAMS RIVER
SOUTH BRANCH WILLIAMS RIVER
- HEAD OF ICE JAM
- APPROXIMATE LIMITS OF FEBRUARY 1976 FLOOD
Chester
North Chester
Chester Depot
Chester Reservoir
Armory
North Street

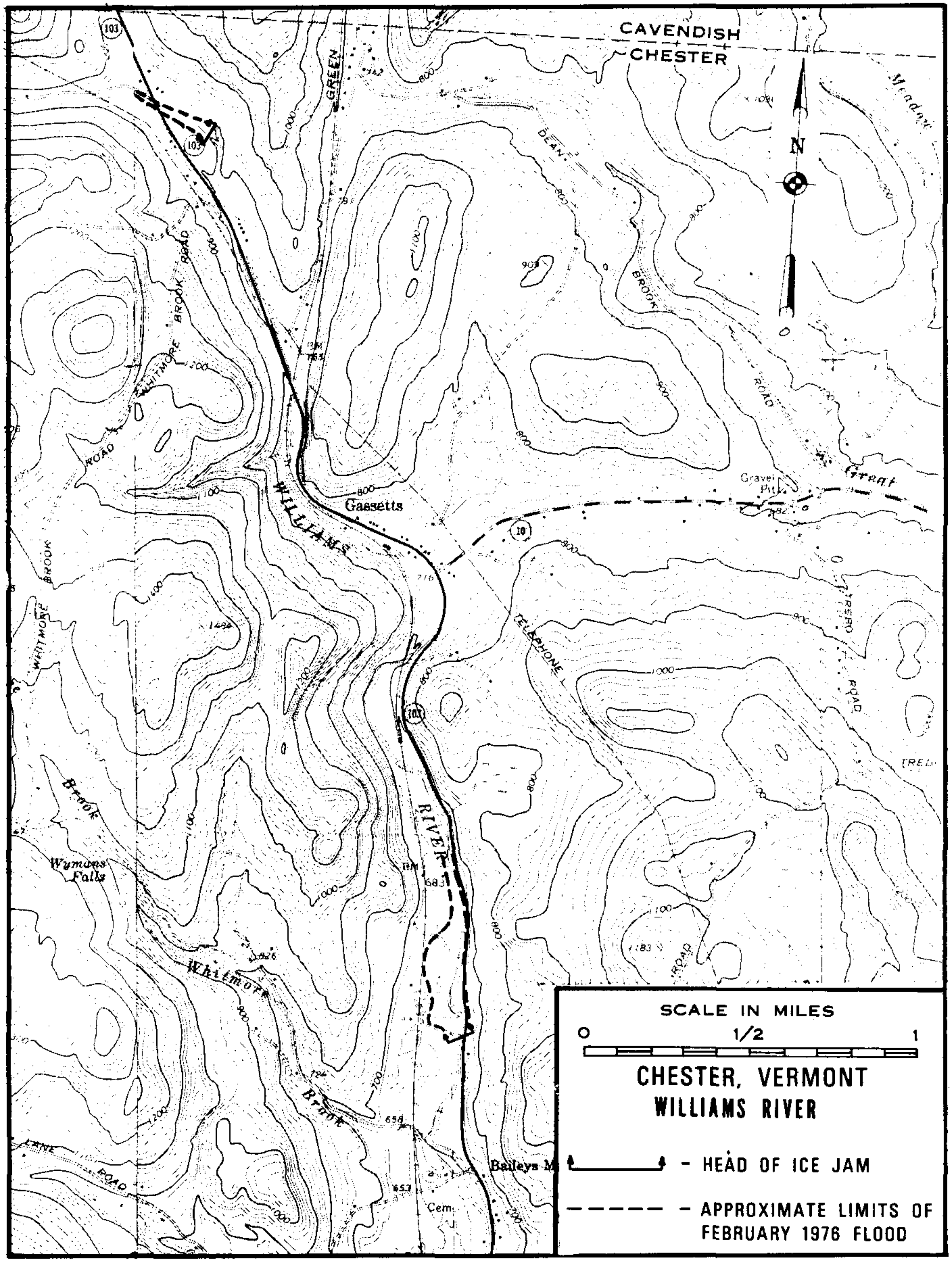

CAVENDISH
CHESTER
N
WILLIAMS
RIVER
Gassetts
Whitmore
Brook
Wymans Falls
Baileys M
Gravel Pit
Great
DEAN
BROOK
ROAD
WHITMORE BROOK ROAD
TELEPHONE
TRED
LANE ROAD
Cem
SCALE IN MILES
0
1/2
1
CHESTER, VERMONT
WILLIAMS RIVER
- HEAD OF ICE JAM
- APPROXIMATE LIMITS OF
FEBRUARY 1976 FLOOD

PLATE 38